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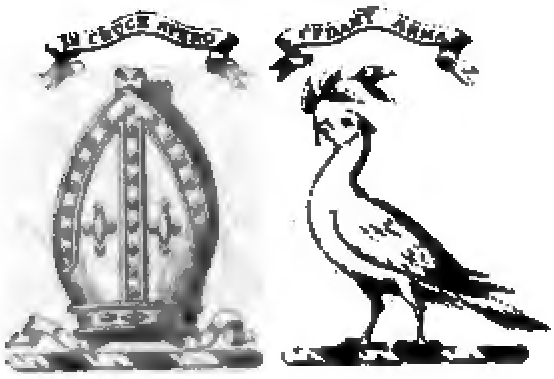

Francis Hubert Barclay

PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

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GEOLOGISTS' ASSOCIATION.

VOLUME THE FIFTH.

1876–1878.

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OF THE

GEOLOGISTS' ASSOCIATION.

ADDRESS

AT THE OPENING OF THE SESSION 1875-76,

NOVEMBER 5th, 1875.

BY THE PRESIDENT,

WILLIAM CARRUTHERS, ESQ., F.R.S., F.L.S., F.G.S., &c.,

Keeper of the Botanical Department, British Museum.

The life of the globe during any past period of its existence is known from the remains preserved in the sedimentary rocks that have been, more or less accidentally, exposed. Our knowledge is bounded by the extent to which the exploration of the rocks has been carried, a boundary always being extended through man's labours. It is absolutely limited by the organic remains actually contained in the rocks. These, even if completely known, would necessarily constitute a defective record. As regards the vegetable kingdom, the strata most abounding in plant remains contain but a small proportion, as we shall presently see, of the vegetation existing at the time of their formation, while many deposits of great thickness, which represent immense epochs in the earth's history, are, as far as we at present know, completely destitute of all trace of plants. The extent of this varying record largely depends on the conditions under which the beds were formed.

Before enquiring into the material of the records, it is, then, desirable to look for a little at the physical conditions under which the rocks were formed, and the influences these conditions exer-

cised in determining the nature and extent of the record. We should not look upon a series of plants collected while a ship touched for a short time at some hitherto unexplored island as the flora of the island. However active and successful the collector may have been, his materials could be accepted as only a contribution towards the knowledge of the island's vegetation. The place visited contained but a small proportion of the plants of the island, and the time spent was too short to procure specimens even of all the plants in the limited locality. The inland and upland plants, as well as those peculiar to bogs and meadows, would probably be wanting on the rocky or wooded shore where the collection was made. Knowing the nature and extent of the limited locality, and the time at the collector's disposal, we might fairly predicate what kinds of plants would be absent from his herbarium. And so the petrified herbarium, spread out on the stone-leaves of the stratified rocks, may, from the conditions under which it has been collected and preserved, represent only a portion of the existing vegetation. Are we able to point out gaps that necessarily exist in the geological plant record, or are we in possession of facts which may, at least, enforce caution in attempted generalisations? If so, we may be saved from erroneous as well as defective estimates of extinct floras.

First of all, we should remember that the plant-bearing sedimentary rocks have been formed under water. The materials of which these rocks are composed have been brought to the place they occupy by running water, which, in its course, had access to a supply of the material deposited, and had velocity and body sufficient to carry it. The arrangement of the particles in the bed has also been the work of water. The organisms buried in the bed have consequently been subjected, for a longer or shorter time, to the action of water. In the case of rapidly deposited gravels and sandstones this action may have operated for a short time, and the specimens may consequently have been buried before any great change had taken place. But plants preserved in shales must have been subjected for a considerable period to this action, and even after they sank to the bottom and were buried in the mud the action of the water would continue. The readily perishable portions of the plant structure would necessarily perish under the influence of this continued water action. The interesting experi-

ment instituted by Lindley as to the capability of different plants to resist the action of water is of great importance in this connection. He placed 177 specimens of plants belonging to the more remarkable natural orders of plants into a large iron tank filled with water. The vessel was placed in the open air and left uncovered and untouched, except when water was added to make up for the loss by evaporation, for two years and one month. The contents of the tank were then examined, when it was found that nothing recognisable remained of thirteen cellular plants, that the two species of Equisetum had also perished, but the six Ferns and one Lycopod were still recognisable. Further, that of the eighteen Gymnosperms, fifteen species, or 83 per cent., were recognisable; of the thirty-one Monocotyledons, twelve species, or 40 per cent., could be determined; and of the 106 Dicotyledons, fourteen species, or 13 per cent., were recognisable. The various plants were selected so as to represent fairly the general structure, as well as the systematic position, of the existing members of the vegetable kingdom. An examination of the list operated upon shows that all plants that were to any considerable extent cellular, and all the herbaceous species, perished, while those that resisted decay sufficiently to be recognised were indurated forms, like the palm and butcher's broom among the Monocotyledons, and the oaks, *Casuarina* and *Dryandra* among the Dicotyledons.

We cannot, then, expect to find cellular structures preserved among fossils, and they are, indeed, rarely met with, even in specimens where the general tissues are well preserved; while plants that were entirely cellular in their structure have altogether perished. Thus, in the extensive flora of the Carboniferous Period, only two exceptionally preserved cellular plants are known, though the physical conditions were singularly favourable for their growth. The humble moss, the creeping hepatic, the epiphytic lichen, and the leafless fungus—all cellular and moisture-loving plants—would find habitats suited to their special tastes in the dense damp and warm Carboniferous forests. There can be little doubt that they flourished there in greater luxuriance and vigour than during any previous, or, perhaps, subsequent, period of the earth's history. Their remains may even have contributed some share to our now amorphous coal, but no recognisable trace of them has been left behind, if we except two fungi—the one described by Mr. Athey from the Newcastle coal field, the other observed by

myself, though not yet described. Both of these owe their preservation to exceptional circumstances. Mr. Athey's specimens are probably masses of indurated mycelium, which, like the "cock-spur" or ergot, were adapted to maintain the vitality of the plant in a dormant condition; while the specimens observed by myself are the mycelium of a fungus which, having penetrated the indurated vascular tissue of a *Lepidodendron*, was thus protected from destruction, and preserved, with these surrounding tissues, by the petrifying mineral.

Specimens of fungi have been found in Irish bogs in so perfect a condition that they have been identified with certainty. They are *Polyporus fomentarius*, Fr., *P. igniarius*, Fr., and *Boletus suberosus*, Sow.—species of a firm and indurated nature, fitted to resist decay. Lindley believed he had obtained a similar woody species from the Coal Measures, to which he gave the name of *Polyporites Bowmani*, and figured and described it in the "Fossil Flora;" but better materials have shown that the fossil is only a large ganoid scale of *Holoptychius Hibberti*, Ag. With the exception of the instances referred to, fungi have not been detected in any of the sedimentary rocks until we reach the Tertiary beds, where a number of minute parasitic forms occur on the leaves of dicotyledonous trees. No less than eighty species have been determined from Eocene strata.

The earliest evidences of plant-remains are generally referred to *Algæ*—indeed, the Cambrian, Silurian, and Lower Devonian systems form the first botanical epoch of Professor Schimper, to which he gives the name of the "Period of Thalassophytes," because only seaweeds are found in these rocks. The evidence of their existence is found in certain markings on the surface of the beds. With one remarkable exception, no trace of structure—not even of carbonaceous stains—has been noticed belonging to any of these supposed *Algæ*. The markings have received specific names, and have been grouped into genera, but it is very doubtful whether there is sufficient evidence to show that they are really impressions of plant forms, especially in view of the interesting observations of Dr. Nathorst, who has noticed on the mud of the Baltic shores markings and impressions produced by flowing water acting on small obstacles, or on plants which are identical with those found on the surface of Palæozoic rocks. The remarkable exception to which I have referred is *Nematophycus Logani*, Carr.

which occurs in the Palæozoic rocks of Canada, the minute structure of which is beautifully preserved, and shows it to have been a cellular plant, most probably a giant seaweed.

Undoubted Algæ are met with in Tertiary strata, as in the Eocene beds of Vienna and Monte Bolca, while the presence of the curiously twisted fruits, which have been called *Gyrogonites*, shows that species of *Chara* lived in Secondary and Tertiary waters. Some of the undoubted plant-remains which have been referred to *Algæ* from the older rocks, are only badly preserved specimens of more highly organised plants, like the *Haliserites* of Devonian age, which is the leafless branches of one of the Lycopodiaceous plants, to which Professor Dawson has given the name of *Psilophyton*.

The only fossil *Lichens* determined with certainty are some fragments of Miocene age which Göppert has discovered in Baltic amber. In the same amber are preserved nearly all the fossil *Mosses* and *Liverworts* that are known.

It cannot be doubted that cellular plants abounded in epochs long before any traces of them have been found in the rocks; indeed, the abundant animal life which peopled the older Palæozoic seas, and the remains of which abound in the rocks, necessitate the coexistence of an abundant marine vegetation, which either directly or indirectly supplied them with food.

Though only one or two forms of cellular plants from undoubted and unmistakable remains are known as forming part of the flora of any Palæozoic or Mesozoic period, we should certainly be in error were we to assert that they were absent from the vegetation of these periods, or, indeed, that they formed an inconsiderable portion of these ancient floras. Their remains are absent from the rocks because the water action, to which all fossil plants have been subjected, has accomplished their complete destruction.

In estimating the relation that the buried remains bear to the actual vegetation of a period, we must further remember that we very rarely meet with these remains in the localities where the plants themselves grew. Unlike most animals, plants are fixed to the spots where they live, and we have, in the main, preserved to us only the dismembered fragments which have been carried by water from their native localities. There are a few exceptions to this, like the coal-beds of the Carboniferous age and the so-called "Dirt-bed" of the Lower Purbeck in the Isle of Portland. But such old land surfaces preserved along with the remains of the vegetation they sup-

ported are very rare. They supply, when they occur, the most certain data for the restoration of an extinct local flora. In the coal we have preserved the whole of the vegetation of the locality, except the plants and portions of plants which readily perished. Roots, stems, leaves, and fruit united to form the coal, and although it may be impossible to recognise them in the generally amorphous mass, they are occasionally preserved in concretions of minerals which were dissolved through the vegetable substance before its organic elements were destroyed, and which, happily, in their segregation and crystallisation, have enclosed the specimens and fixed their tissues by replacing the perishable organic structures with the imperishable mineral. Such concretions occur in the Yorkshire and Lancashire coal fields, where they are called "coal-balls;" and to them we are indebted for much of the accurate and ever-growing knowledge we possess of the structure of coal and the nature of the plants which have gone to form it. In the Portland "Dirt-bed" we have only the trunks of the cycadean and coniferous trees, converted into amorphous silex, still occupying their original position. No traces of leaves or fruit have been found associated with these trunks.

The fossil vegetable remains are, however, chiefly fragments of dead and dismembered plants borne to their resting-place by water. As long as the specific gravity of the fragments was less than that of the water, they floated and rotted; when completely water-logged and heavy, they sank to the bottom as soon as the velocity of the current was insufficient to make up for the excess of weight. Thus we find immense trunks enclosed in sandstone rocks, the force of the current being evidenced equally by the size of the fossil as by the nature of the rock in which it is bound. The porous sandstones, permitting the passage through them of water and oxygen, have secured the destruction, by slow combustion, of the substance of the wood, where it has not been fixed or replaced by foreign minerals. There remains in such cases only a cavity representing the fossil, which is either empty or filled by a cast of the stem formed of the amorphous substance of the enclosing rock forced into the cavity, or of some mineral diffused through the rock, which has crystallised in the cavity. When this dissolved mineral had access to the wood before decay has taken place, a pseudo-morph of the vegetable structure preserving its minutest details in marvellous perfection is produced.

The plant remains which were floated into still water were buried in mud, and this in the older rocks is now generally indurated into shales. The mud having closely invested the plants and prevented the access of water or oxygen, has preserved their original elements, though a metamorphic or chemical rearrangement of these elements has taken place, resulting in the production of a homogeneous substance, having the form without the structure of the original organism. This process may be called carbonisation, as opposed to that of mineral replacement or petrifaction.

To the operation of these conditions we owe the preservation of the plant-remains which form our great beds of coal. Chemical changes have taken place, but the hermetically closed envelope of the under and roof clays has confined these changes to each particular bed, and has prevented the escape of volatile or dissolvable elements to any great extent. These coal beds then preserve nearly all the original elements of the plants, without almost any of the structures into which they were originally built up.

Having thus passed in review the conditions under which the carbonised or petrified remains of plants have been preserved, we are in a better position to enquire to what extent the floras to which these remains belong may be expected to be represented by them.

Fossil plants are rarely found, as we have seen, in the localities where they grew. The association of the vegetation with the soil which supported it, when it occurs, supplies valuable help to a right interpretation of the flora. We thus learn from the soil on which the coal beds rest, as well as from the great expanse of the coal seams themselves, that in the Coal Measures we are dealing with the vegetation of extensive swampy plains. The contemporary upland vegetation is represented by the trunks of trees and the indurated fruits found in sandstone deposits, as at Edinburgh and Manchester. These certainly testify that at least some, if not all, of the woody trees which clothed the higher ground were Gymnosperms. The areas of dry land supplying the abraded materials now forming the shales, sandstones, and conglomerates of the Carboniferous age must have been immense. And these immense areas were, without doubt, covered by vegetation, probably as abundant as the land vegetation of the present day, and no doubt more varied than the remains known to us indicate. But just as our dry-land vegetation now lives and perishes, leaving little to testify in future ages to its nature or extent, so, with the

exception of the trunks and fruits to which I have referred, no record remains of the upland floras of the Carboniferous period.

We have no means of estimating the relation between the marsh and dry-land Carboniferous floras. The woods supply only a few specific forms belonging to these types, perhaps, of generic value, but the fruits described by Göppert, Berger, Brongniart, Lesquereux, and others show that there must have been a large series of generic as well as of specific types of gymnospermous plants clothing the higher lands. The marsh flora, though almost confined, as far as its remains testify, to three natural Orders, was nevertheless remarkably numerous in specific forms.

If we may venture to suppose that the relation between the marsh vegetation and the entire flora of these Palæozoic ages, was at all similar to that existing between the bog plants of our country and its entire flora, we may form some estimate of the imperfections of the Carboniferous plant record. Our marsh peat contains the remains of oak, fir, alder, and birch, and more rarely of ash, hazel, mountain ash, and willow among trees; of two or three species of heath, the bog myrtle, and the cranberry; and of the sundews, the bog bean, and some twenty other marsh plants, together with a few grasses, and sedges, some horsetails, and, most abundant of all, one or two species of bog-moss. Probably the entire enumeration would amount to 60 species, or less than four per cent. of the whole British flora, omitting the cellular plants entirely. Prof. Schimper records 504 species from the beds associated with the Coal Measures proper, excluding the gymnospermous woods and fruits. Let us allow for errors arising from the description of different parts of the same species under two or more specific or even generic names, by deducting two-thirds of this number, and we would have 167 species remaining as a marsh flora, representing, if the proportion is of any value, an upland flora of 500 species, of which we at present know the remains of only about 50 species.

But, on the other hand, it may be that these Palæozoic highlands were peopled by a gymnospermous vegetation, consisting of a comparatively small number of species, just as in our own day extensive regions of mountainous countries are tenanted by a few species of coniferous plants.

Similar caution in generalisation must be exercised right through

the whole series of sedimentary strata. We must remember that the physical conditions under which the plant remains were deposited have exercised, so to speak, a power of selection which has set aside whole groups of plants, and left out the representatives of immense areas of vegetation. In the Palæozoic measures, this selection was exercised to the exclusion of nearly all plants that were not vascular cryptogams. The *Pothocites Grantoni* is the only known certain relic of phenogamous vegetation higher than a Gymnosperm. And again, this selective power in the Eocene deposits has rejected the cryptogamic members of the then existing vegetation, while at Sheppey it has conserved to us innumerable fruits, only a tithe of which have been figured and described by Bowerbank; and at Alum Bay, Bournemouth, and other localities, it has spread out hardy foliage chiefly of deciduous Dicotyledons on the surface of white clays, and so preserved the evidence of an extensive flora about which we may hope by and by to know more, through the persevering and successful labours of Mr. J. S. Gardner.

Let me, now, in a few sentences, refresh your memories as to the great divisions of the vegetable kingdom.

It is not possible to range the members of the vegetable kingdom in a strictly linear series; nevertheless, an approach to such a series may be made, at least, as far as it is necessary for our purpose to go, without very serious violence. The characters upon which the most natural grouping is based, are derived from the organs of reproduction. And it is important for us to observe that, as a rule, the more rudimentary organs of reproduction are associated with the more simple organs of vegetation.

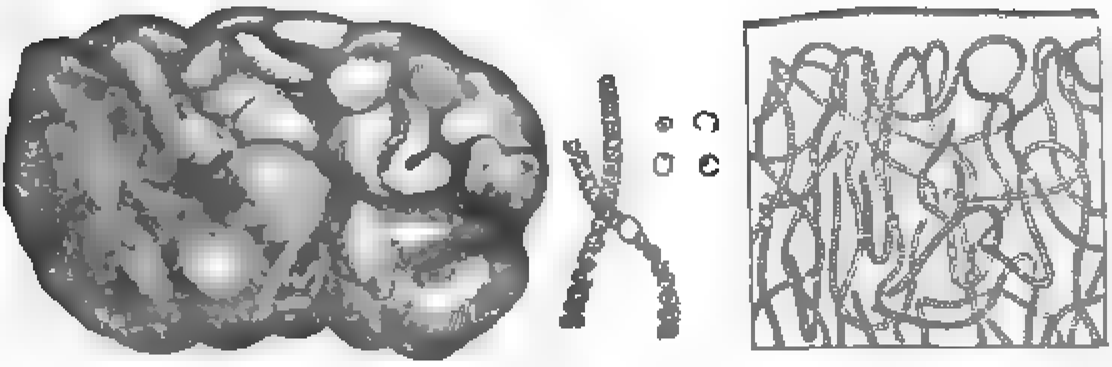
The vegetable kingdom was divided by Linnæus into Phanerogams and Cryptogams—a division which is as satisfactory now as it was a century ago, although all the characters that were then ascribed to the Cryptogams have one by one been discovered to be incorrect. Still, however, the seed-bearers and the spore-bearers, which are the two great groups of Linnæus, separate the more highly organised plants from those that are lower.

Looking at the organs of vegetation alone, the Cryptogams are obviously divided into Thallogens and Acrogens. A nearly parallel division into Cellulares and Vasculares was proposed by Decandolle, which is of special value to the geologist, because of the

absence of cellular plants from sedimentary deposits, to which I have already referred at length. The Acrogens are all Vasculares, except the Mosses and Hepaticæ, which, therefore, belong to Decandolle's lower division of Cellulares.

The simplest Thallogens are those *Fungi* and *Algæ*, which, as far as at present known, have their spores produced from the contents of a single cell, and which are, therefore, asexual. These

FIG. 1.



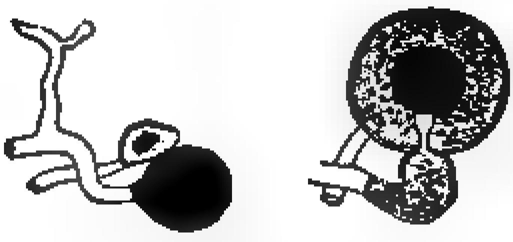
a. c. b.

FIG. 1.—*Nostoc*. a. General aspect of a mass of the plant, with b. magnified portion, immediately below the surface, and c. still more magnified fragments of two threads, and of separate spores produced from the contents of a single cell.—(Thuret.)

include *Nostoc*, *Oscillatoria*, and *Bacteria*. From the absence of chlorophyl, it has been proposed to place *Bacteria* among the Fungi; and an advocate of the genetic relationship of all plants, has recently suggested that in *Bacteria* we have the starting-point of the development of the vegetable kingdom.

Rising in the scale, we have the remaining Thallogens, in which there is sexual reproduction, from the action of the contents of one cell upon those of another. This group includes the great majority

FIG. 2.



a. b.

FIG. 2.—*Peronospora Alsinearum*, Casp. a. Young oogonium and antheridium. b. The antheridium sending out a fecundating tube into the oogonium.—(De Bary.)

of the Algæ and Fungi, aud all the Lichens, being variously modified in different divisions.

The Mosses and Hepaticæ form a group of Acrogenous Cellulares, though the Hepaticæ include among them some plants which

are true Thallogens. The sexual reproductive organs in these two

FIG. 3.

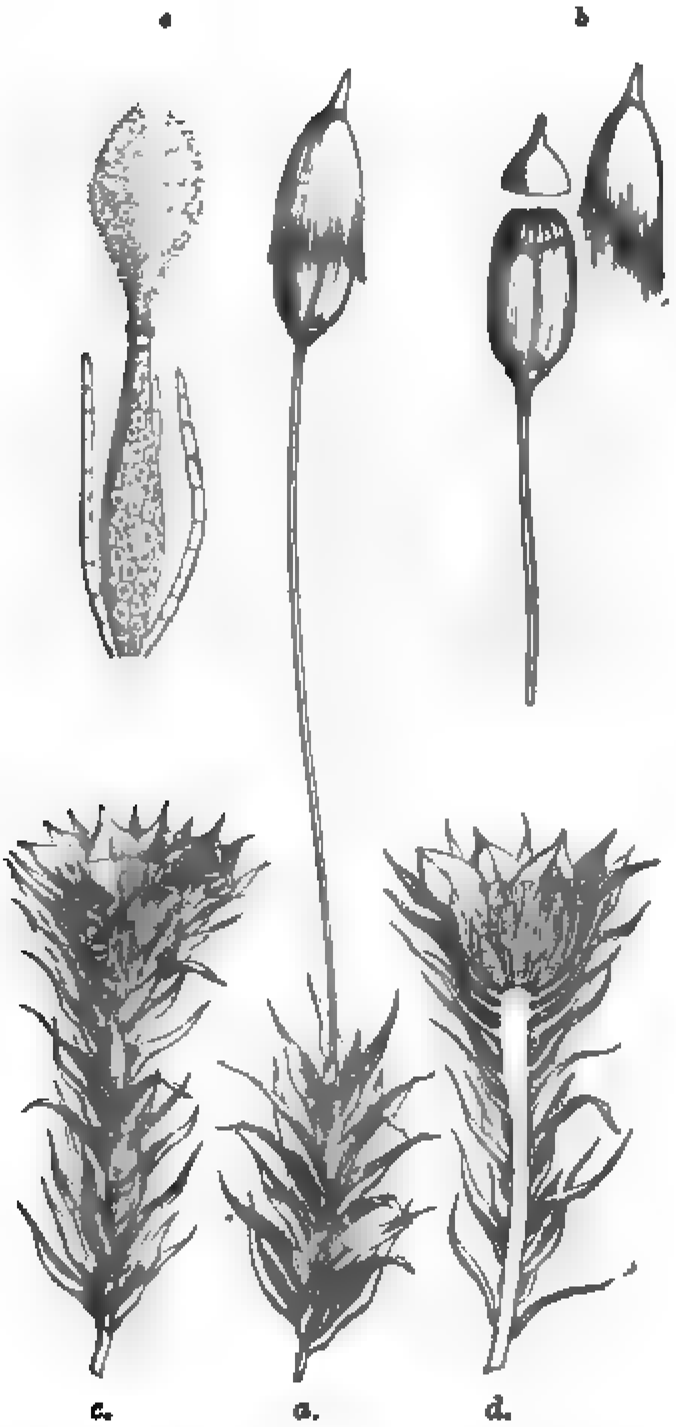


FIG. 3.—*Polytrichum commune*, Linn. *a.* The upper part of a plant with its capsule. *b.* The capsule, with the lid and calyptra detached. *c.* A male plant. *d.* Section of the same, showing a number of elongated sacs and paraphyses seated on the end of the axis, and surrounded by a rosette of leaves. *d.* A single antheridian sac, with three paraphyses, the contents being discharged at the summit of the cell.

Orders are more complicated, being differentiated into Antheridia and Archegonia.

The Vascular Cryptogams consist of five Orders, in three of which, the Ferns, Moon-worts, and Horsetails, the spores are uniform in size, while in the other two, the Rhizocarps and Club-

FIG. 4.

FIG. 4.—Male and Female Organs of *Pteris*. *a*. Spermatozoids from the antheridium. *b*. Single Archegonium.

mosses, they are of different sizes. In these two groups the macrospores and microspores foreshadow the differentiation of organs in the more highly organised phanerogamous plants.

FIG. 5.

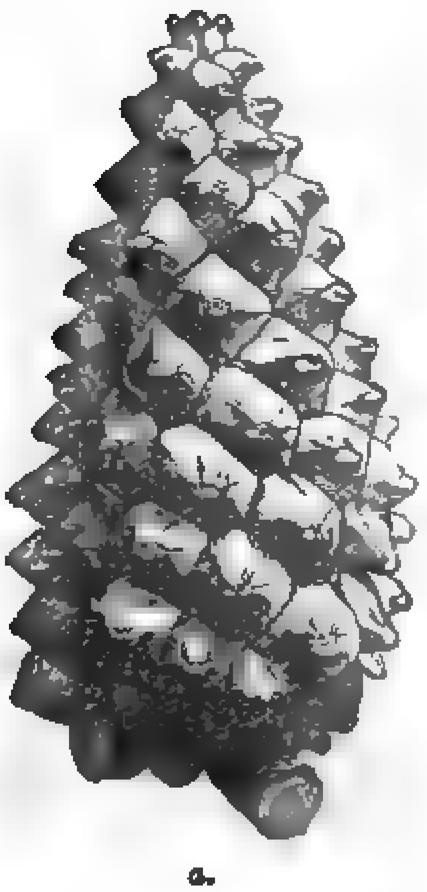


FIG. 5.—*Pinus sylvestris*—the Scotch Fir. *a*. Cone, natural size. *b*. Male inflorescence, with a single stamen separate. *c*. Female inflorescence, with back and front aspects of a single scale, showing the two ovules at the base of the scale; and portion of a scale with section of the naked ovules.

The Phanerogams are divided into two well-marked groups, from the manner in which the seeds are borne. In the lower group, the Gymnosperms, the seeds are naked; while in the Angiosperms they are enclosed in a cavity composed of one or more carpellary leaves. The Gymnosperms include two groups of plants of great geological importance, the Cycads and Conifers. The ovule has generally a single covering, and is borne on the naked surface or the margin of altered leaves, which never form a true ovary or vessel enclosing the seeds, though they often enlarge to protect the seeds,

FIG. 6.

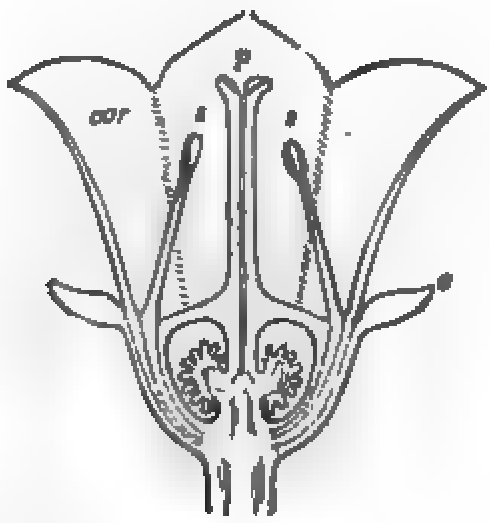


FIG. 6.—Section of the Flower of a *Campanula*, showing the relative position of the various parts. *c.* calyx, *cor.* corolla, *s.* stamens, and *p.* pistil, containing the ovules in the ovary, and surmounted by the style and stigma.

as in cones of the fir. The Cycads have the general aspect of Palms or Ferns, but agree with Conifers in the structure of their seeds.

FIG. 7.

FIG. 7.—Longitudinal section of the seed of *Calla*, showing the monocotyledonous embryo.

FIG. 8.

FIG. 8.—Section of the stem of a Palm, showing the arrangement of the vascular bundles in an endogenous stem.

In the Angiosperms the ovules are produced in the interior of a closed vessel or ovary, which terminates in a stigma, upon which the pollen grains germinate. The pollen tube reaches the ovule, and after fertilization the embryo is produced.

The structure of the embryo in the Angiosperms supplies good characters for their division into Monocotyledons and Dicotyledons. The single cotyledonary leaf in the seed of the Monocotyledons is associated with other distinguishing characters, the most obvious of which is the endogenous growth of the stem, while the embryo of the Dicotyledon has two cotyledonary leaves, and the stem is exogenous. Some systematists, overlooking the

FIG. 9.

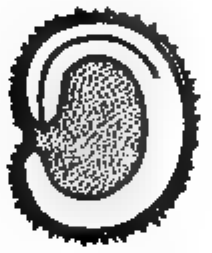


FIG. 9.—Dicotyledonous embryo of *Agrostemma Githago*, Linn. Corn-cockle.

FIG. 10.

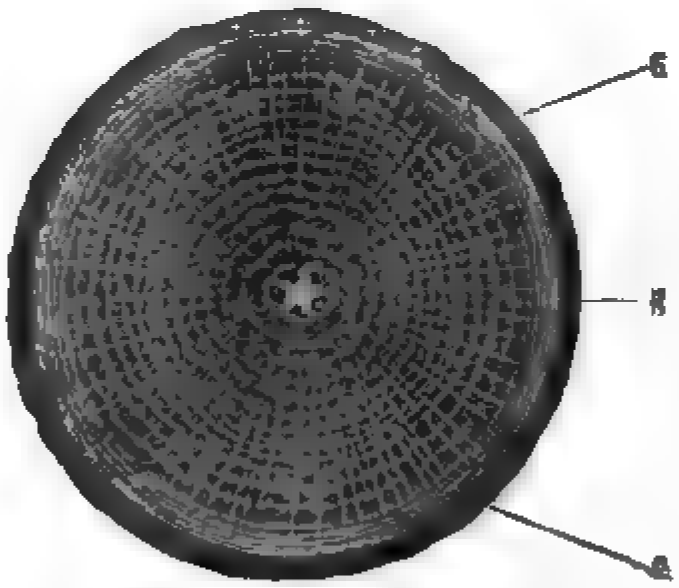


FIG. 10.—Transverse section of the trunk of Oak (*Quercus Robur*, Linn.), of eighteen years' growth, showing the exogenous growth. A. The new or sap wood, added exogenously below the bark, E. B. The old or heart wood.

fundamental differences in the seeds, have, from the exogenous growth of the stems of Gymnosperms, placed them beside the Dicotyledons, and thus separated the two closely allied groups of Angiosperms.

We must content ourselves with this rapid sketch, and not trace further the divisions of the vegetable kingdom; and our review of the extinct forms of plant-life must be confined to the same main lines.

The presence of *Algæ* is determined chiefly by impressions on the surface of the laminæ of stratified rocks. These impressions are without structure, and supply little more than flattened outlines to guide in estimating the nature and position of the plants which have produced them. The presence of Algæ has, from such materials, been determined in Silurian and all subsequent formations. The

minute spiral spores of *Chara* are met with in Oolitic rocks, and they are singularly abundant in some Tertiary beds.

Fungi are known in the Palæozoic rocks from their mycelium being preserved in woody stems of Carboniferous age. It is remarkable that no evidence of epiphytal Fungi has been detected on the fronds of ferns in the Coal Measures; the earliest beds in which such fungal forms have been observed are of Permian age, where they have been noticed on ferns. In the Oolites they are seen on the leaves of Cycads, and they abound on a variety of phanerogamous leaves in Tertiary strata.

Lichens have as yet only been observed in amber and on lignites of Miocene age.

Mosses and *Hepaticæ* are also known only as Tertiary plants being found in Eocene and Pliocene deposits.

The greatest number and variety of fossil plants belong to the natural Order of *Ferns*. Our first knowledge of them is in rocks of Devonian age, and they are found in the deposits of every subsequent period. One remarkable type, not uncommon in Palæozoic rocks, has become extinct—that of which Corda's *Stemmatopteris* may be taken as the representative. It differed in the structure of its stem, as much from the majority of its contemporaries, which were of the same type as living tree ferns, as the stem of a monocotyledon differs from that of a dicotyledon. Yet the foliage and fruit characters of the two forms appear undistinguishable. The ferns found in the Yellow-sandstone of the South of Ireland, of Upper Devonian age, are singularly well preserved, and they exhibit, a structure both as regards their vegetative and reproductive organs that makes it difficult to separate them generically from living forms.

The *Equisetaceæ* have been with the *Lycopodiaceæ* and *Gymnosperms*, the contemporaries of the Ferns, from their first appearance in the Devonian period. Though these Palæozoic horsetails had a more complex organisation than their later representatives, yet they cannot be separated more than generically from them, and they supply a variety of types to a natural Order which is represented in existing vegetation by a single genus, and that a genus which has very little variation in the different known species.

The *Lycopodiaceæ* are also very closely related to the living forms; the differences that have been detected being mainly the greater complexity of the foliage and stems. The fruits of the Palæozoic *Lycopodiaceæ* differ only in their greater size. No trace

of the order has been observed in strata of the Tertiary period, and only doubtful forms have been referred to *Lycopodiaceæ*, in Secondary strata.

Rhizocarps are known fossil only in Eocene deposits, and belong to species of existing genera.

As already noticed, the *Gymnosperms* appear with the Ferns in Devonian rocks. The number of forms largely increase in the Carboniferous series, and all belong apparently to the Taxineous group of the *Coniferæ*. The *Abietineæ* appear in Permian strata, and greatly increase through the later deposits. Some fruits of the Palæozoic Gymnosperms are thought to have belonged to the *Cycadeæ*, but the earliest remains that can with certainty be referred to this Order, are found in Secondary rocks. A remarkable group, with a fleshy fruit, analogous among the *Cycadeæ* to that of the *Taxineæ* among Conifers, occurs in Oolitic and Cretaceous strata, but is now extinct.

The first evidence of *Monocotyledonous plants* is the spadices of the remarkable Aroideous fossil called *Pothocites*, found in the lowest beds of the Carboniferous series, near Edinburgh. The anomalous spiral fruits first found in the Carboniferous beds, and persisting down to the Wealden, which are called *Spirangium*, were most probably Monocotyledons. The remains of this great division of flowering plants are more abundant in the Secondary rocks, and the forms preserved have all been referred with little uncertainty to existing Orders. These plants form a large proportion of the Tertiary Floras.

Dicotyledonous plants suddenly appear in beds that are referred to the Upper Cretaceous series, and not only in great abundance, but in large variety of form, representing all the great groups into which this important section of the vegetable kingdom is divided. Some of the leaf-forms have not been correlated with living forms, and they may represent extinct genera; but sufficient evidence cannot, I believe, be obtained from foliage alone to determine with absolute certainty the systematic position of the unknown plant, to which it belongs. Only a few of the numerous forms found in the latest Secondary and the Tertiary periods have not been referred to genera represented by living plants.

The bearing of the facts which I have thus rapidly placed before you, on popular speculations, though very tempting, must be deferred to another and more fitting opportunity.

ADDRESS

AT THE OPENING OF THE SESSION 1876-77.

NOVEMBER 3RD, 1876.

BY THE PRESIDENT,

WILLIAM CARRUTHERS, Esq., F.R.S., F.L.S., F.G.S., &c.,

Keeper of the Botanical Department, British Museum.

Having, a year ago, considered the conditions under which the remains of plants have been preserved to us, and the nature and extent of the geological record of the vegetable kingdom, I propose to occupy this evening in investigating the bearings of these facts upon the popular speculations as to the origin of the present life forms of our globe.

Until a recent period, little diversity of opinion existed amongst students of science in regard to the origin of these organic forms. The position stated by Moses in the opening sentences of the Old Testament, in which all matter, organic and inorganic alike, is traced to the operation of an eternal and supernatural Creator, was universally adopted, though his narrative was often misunderstood and misinterpreted.

In the beginning of the century Lamarck proposed his evolution hypothesis. He held that all organisms were derived from some few simple original forms, which had come into existence by spontaneous generation out of inorganic nature. His hypothesis found a few supporters, but it was comparatively neglected by men of science until Darwin, in 1859, published his "Origin of Species by means of Natural Selection." This work wrought—at least, in this country—an almost complete change in opinion as to the origin of our present life forms.

It is no part of Darwin's purpose to account for the origin of life; his hypothesis deals only with the origin of the forms of organic life. It operates upon beings already existing. The necessary primordial organisms owe their existence, according to Darwin, to

a Creator. Endowed with the properties of growth, organisation, and reproduction, and influenced by the laws of hereditary variation, over-production, and natural selection, these simple created germs have, without direction or control, produced the various forms of vegetable life which have lived, or are now living, on the earth.

The method of this development may be thus briefly stated:— Besides the characters transmitted by plants to their descendants, new characters arise in some of the progeny which were not possessed by the parent. When these new characters are transmitted to descendants, and are permanent, the plants possessing them become a variety. Some plants have a special tendency to variation, others are remarkably constant in their characters. No explanation has been suggested of the reason for these differences, or of the cause of the appearance of new characters. The differences are at first small. Their continuance depends upon the capacity they supply the organism for battling with external causes. In course of time further characters appear, or the old become intensified, and in the struggle for existence, the varieties only, or, it may be, the parent form, which possess the characters best fitted to resist the prejudicial influences that surround them, are able to maintain their ground. The less fortunate varieties, and with them most probably the parent form, perish; and thus the connecting links between the common descendants of the original stock are destroyed. These descendants, becoming more pronounced in their characters, are recognised as species. Accordingly, the only difference between a variety and a species is the amount of divergence and the constancy of the divergent characters. And these, in a greater degree, are, according to this view, the only differences between a species and a genus.

It is, then, concluded that all forms now observed in the vegetable kingdom are due to the continual accumulation of differences in the genetic evolution of the existing plants from the one or few simple original forms; that the natural system of plants is the external expression of this phylogenesis, or genetic relationship; that the development of a plant from the embryonal cell to the perfect individual is a short and quick repetition of the genetic development of the tribe to which it belongs; and that the rocks of the earth reveal, so far as the record of life is preserved, the various steps by which the phylogenesis was actually accomplished.

The evidence for or against this hypothesis must be sought in the records of the past history of the earth, for whatever progress has been made in collecting collateral evidence, no single case of evolution of one species from another has come within the observation of man. The plants pourtrayed on the ancient paintings and sculptures of Egypt, the fruits placed in coffins with embalmed bodies, and the fruits and seeds found in ancient lake dwellings all belong to existing species, with which they agree in the most minute and apparently accidental particulars. The existing order of plants, if it be due to genetic evolution, supplies no proofs of it.

Nor can the proofs be found in the series of changes which we may observe taking place in the evolutions of the fully-organised plant from the germ cell of the ovule ; for though we trace in these changes some structures more or less remotely analogous to lower plant organisms, each of them is but a stage in the life of the individual plant. Any arrest of this progress means death to the organism.

The evidence for evolution must be found in the rocks. However varied the existing forms of plants are, if this hypothesis be true, they must all have been connected together by gradational forms ; so that from the highest plant to the simplest *Bacteria* there must be in time a series of gradations by which we can pass from the one end of the series to the other. And these intermediate gradations are the fossil forms of the successive geological epochs preserved, more or less completely, in the sedementary deposits.

The palæontological record is very incomplete. Little more than a few representations are found of what must have been extensive floras, and even when a flora is fairly represented, it may occur in the midst of a series of comparatively barren strata. The record is like a tablet containing the remains of an unknown inscription represented by only a few of its numerous letters—the value of the letters that are intact is known, and each still occupies on the stone its proper position in relation to the unknown as well as to the other known letters of the inscription. In attempts to decipher the lost writing no violence must be done to these known letters or to their relative positions in filling up the blanks. Any interpretation that does not respect these conditions carries with it its own condemnation. In his hypothesis, Darwin has given us

such a reading of the life of our globe. Some of the letters still preserved are yet so obscure that their value is doubtful. They have suffered injury; portions have been destroyed, and the fragments remaining may be differently interpreted. There are fossils whose nature and systematic position are, at least, subjects of dispute. These, for our present purpose, must be reckoned as blanks. But beyond them there is a large series of plant-remains completely and accurately known which supply a fair representation of the great events in plant life that have taken place in the earth since Palæozoic times. And these are more than sufficient to establish or destroy this hypothesis by their testimony.

A hypothesis can be substantiated only when it is in entire accordance with all known facts. The legal doctrine that "the exception proves the rule," though not unfrequently quoted in science, is the very reverse of the truth. Here the exception disproves the rule, for the rule is but the expression of the united testimony of all related facts, and as soon as a fact turns up that is opposed to a rule, that rule must either be enlarged to include it or set aside as no longer in harmony with nature.

Consider, now, the hypothetical phylogenetic history of the vegetable kingdom as advanced by Hæckel and other advocates of evolution, and the bearing on this history of the ascertained facts of palæontology.

The most rudimentary plants are either Fungi or Algæ. The notion lately suggested that the primal stock of the vegetable kingdom was a simple fungus may be at once dismissed, as it is impossible to imagine how a group of plants which, like the Fungi, live on organised food, chiefly obtained from other plants, could exist before there were any plants to supply them with that food; and besides, no indication of a fungus has been detected in the older Palæozoic rocks.

The presence of chlorophyl in Algæ is thought by some to place them in a higher position than the Fungi. In other respects the Algæ are the simplest and least perfect of all plants, and among them, consequently, might be found the most ancient of all vegetable organisms, out of which all other plants have originated. In the course of the primæval ages the unicellular Algæ produced the Green-, Brown-, and Olive-spored Classes and the Characeæ.

"We may suppose," writes Hæckel, "that the submarine forests of the primordial period were formed by the huge Brown

Algæ or Fucoideæ. The many-coloured flowers at the foot of these gigantic trees were represented by the gay Red Algæ or Florideæ. The green grass between was formed by the hair-like branches of Green Algæ or Chloroalgæ. Finally, the tender foliage of ferns and mosses which at present covers the ground of our forests, fills the crevices left by other plants, and even settles on the trunks of the trees, at that time probably had representatives in the moss and fern-like *Siphoniæ*, in the *Caulerpa* and *Bryopsis* from among the class of the Primary Algæ."

What is the testimony of the rocks? The abundance of animal life implies a corresponding abundance of vegetable life, but the hard parts of marine animals have been preserved, while the cellular Algæ have left the most imperfect record. The great extent of the primæval vegetation is testified to by the enormous quantity of carbon contained in the most ancient rocks. Dr. Dawson says that "it is scarcely an exaggeration to maintain that the quantity of carbon in the Laurentian rocks of Canada is equal to that in similar areas of the Carboniferous system."

But notwithstanding such evidence of an abundant flora in primordial times, the record of plant forms is very imperfect, the only markings that can be considered as due to plants having been referred to but sixteen species of Algæ. These markings are mere surface impressions, in no case exhibiting any trace of the original structure, and all are so vague that it is impossible to speak with any certainty of the systematic position of the organisms producing them. It must, however, be remembered that the nature of the plants which could live in the conditions under which these deposits were formed, and the changes that have taken place in the primal strata since their deposition, prevents us expecting any extensive representation of these early floras. But so far as the indications of the plants have been preserved, it may be said that they do not contradict the evolutionist who looks upon Algæ as the primæval plants. While making this admission in relation to the vegitation of these older rocks, I must protest against the practise of completing the geological record of life forms, by filling in particular groups without any authority except the writer's impression of the necessities of an adopted hypothesis, and then basing arguments on these assumptions in support of the hypothesis which created them. So completely has phylogenetic evolution become the creed of some leading naturalists that they unwittingly

proceed in this manifestly unphilosophical method. But it is a first axiom, though one often forgotten, in this as in every scientific enquiry that no step can be made in advance which is not based on fact.

In the hypothetical phylogenesis of the vegetable kingdom, we come to the evolution from the Algæ of Fungi, Lichens, Mosses, and Hepaticæ, all of them cellular plants. They are supposed to have come into existence with the Devonian Period, the beginning of the later Palæozoic series. The mycelium of one or two species of Fungi has been detected in the Coal Measures, but, with this

FIG. 1.

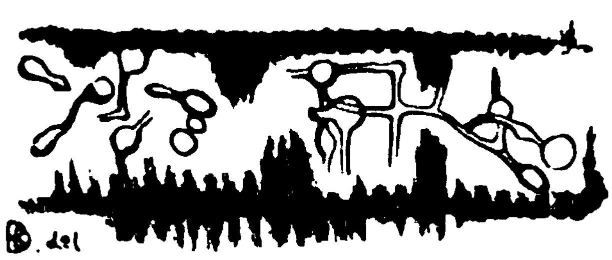


FIG. 1.—Mycelium of a Fungus from the scalariform axis of a *Lepidodendron* from the Coal Measures.

exception, there is no trace of any of these plants in Palæozoic rocks.

The later Palæozoic rocks abound in plant-remains. The first evidence of land plants is found in the Devonian rocks, and here, at their appearance, the three principal groups of the Vascular Cryptogams appear together in highly differentiated forms. All of them — Ferns, Horsetails, and Lycopods — possess the same essential structure and organisation as their living representatives, and in all the subordinate points in which they differ from them it is in possession of characters indicative of higher organisation— whether we look at the vegetative or the reproductive organs— than are found in existing forms.

These three classes of Vascular Cryptogams are held together by well-marked characters, which they have in common, and by which they are separated from the cellular plants below them, and from the phanerogamous plants above them. They all possess fibro-vascular bundles developed in fundamental tissue, and a true epidermis. In the process of development from the spore these plants exhibit two generations, in the one of which the spore produces a temporary pro-thallus, on which the sexual organs are borne, and from the fertilised archegonium the new and perfect plant proceeds, which produces the asexual spores in Ferns and Equisetaceæ and the macro-spores and micro-spores in Selagineæ.

The three classes are clearly separated from each other by obvious characters. The *Ferns* have a slender or tree-like axis supporting the leaves, which are larger and more perfect than in any other group of plants. The spores are produced on the margin or back of the leaf; they are simple, of one kind, and produce a green leaf-like monœcious pro-thallus. The *Equisetaceæ* have a fistular jointed stem, with the leaves reduced to a small sheath crowning the apex of each internode. The leaves are scarcely more rudimentary in any group of plants. The spores are borne on altered leaves, forming small cones, which terminate the axis; they are furnished with hygrometric elaters, and are of one kind only; when they germinate they produce a generally diœcious thallus. The *Lycopodiaceæ* have an elongated axis (except in *Isoëtes*), with small simple leaves. The great majority of the plants of this order belong to the two genera *Lycopodium* and *Selaginella*, which so closely resemble each other in general appearance that the species found in Britain are referred to one genus in nearly all our Floras, yet they differ greatly in their reproductive organs. The spores are borne in the axils of more or less altered leaves, but in *Lycopodium* they are small and of one kind, while in *Selaginella* there are two kinds, called macro-spores and micro-spores. The macro-spore produces the pro-thallus, and only the part bearing the archegonium protrudes from the spore. We need not consider the structures and affinities of the *Rhizocarps*, because there is no certain evidence that they have been detected as fossils.

The three Orders appear together, as I have said, in the later Palæozoic rocks, and that not in simpler and more generalised types, but with more varied and more complex structures than are found in any of their living representatives. Thus among Ferns there is lost a remarkable group with a fundamentally different type of structure, which was contemporaneous in the Palæozoic ages with the types of ferns that have been represented all through the epochs and are now abundant on the globe. The Equisetaceæ had a large number of generic groups; their stems were arborescent, the leaves large, and the fruit cones protected by special scales, but the spores were similar in size and form to those of the living Horsetails, and were furnished, at least in some cases, with hygrometric elaters. The Lycopods were also huge trees, and were represented by several generic groups. The structure of the

stem, while fundamentally agreeing, like that of the arborescent Equisetaceæ, with the stems of the living forms, was more complex, being suited to their arborescent habit.

The floras of the later Palæozoic periods include higher elements than vascular cryptogams, for in the Devonian series we have Gymnospermous plants, increasing greatly in number and variety in the Carboniferous period; and in the Calciferous-sandstone, at the very base of the Carboniferous strata, there has been found a true Angiospermous plant.

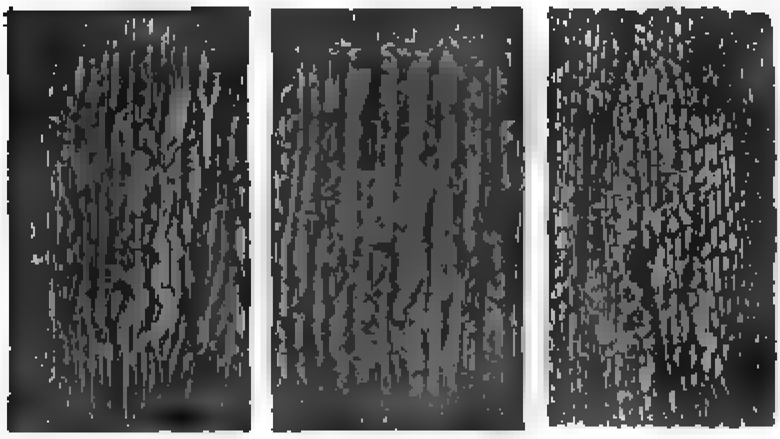
The step from the spore-producing Cryptogam to the seed-bearing Phanerogam is a very great one. No doubt there is a general external resemblance between a lycopod and a conifer, and many points of analogy between the development of the seed and the various stages through which the lycopod passes from the germination of the spore to the growth of the fertilised archegonium. But like is here, as it is often elsewhere, an ill mark, for the resemblances are purely superficial. The minute tissues of the conifer, as well as the method in which they are arranged, differ entirely from anything either in the existing or extinct lycopods, while the production of a seed, even though it be without a protecting ovary or fruit, at once and widely distinguishes the Gymnosperm from the spore-bearing Cryptogam.

According to Hæckel, the Gymnosperms sprang out of the Lycopods during the Carboniferous, or possibly during the Devonian, period. But undoubted Coniferous wood was discovered by Hugh Miller in the Devonian rocks of Cromarty, and several anomalous woods have been discovered by Unger in

FIG. 2.

FIG. 2.—Fragment of Coniferous Wood, found by Hugh Miller in an Old Red nodule at Cromarty.

FIG. 3.



a. b. c.

FIG. 3.—Magnified Sections of the Coniferous Wood from Cromarty. a. is at right angles to the medullary rays; b. parallel to the rays; and c. is a transverse section.

the Thuringian rocks of Devonian age, which were referred by him to the Coniferæ without any positive evidence except the absence from their structure of ducts. Had these been of earlier age than Miller's Cromarty wood, they might have been looked upon as one of the steps leading up to the true Coniferous structure.

The Calciferous-sandstones at the base of the Carboniferous series contain numerous specimens of Coniferous trunks, which have been drifted into the sandstones, and are well preserved through mineral replacement. These trees had attained to an immense size. A fragment of a trunk in the British Museum, from the neighbourhood of Edinburgh, is nearly forty feet long, twelve feet in circumference, and almost uniform in diameter throughout its length. It has, with other specimens, been described by Sir Robert Christison in the "Transactions of the Royal

FIG. 4.

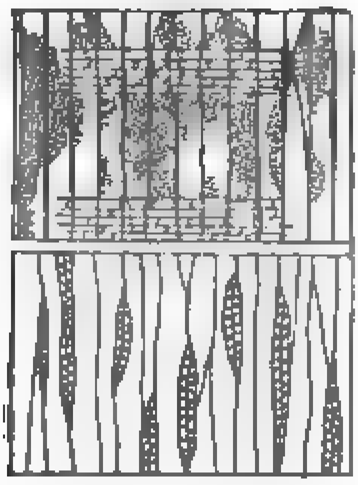


FIG. 4.—Longitudinal Sections of a Fragment of the Great Tree from Edinburgh, now in the British Museum. The Upper Section being parallel to the medullary rays, and the Lower at right angles to them.

Society of Edinburgh." Coniferous woods become more abundant as we rise in the Carboniferous measures, but the most important testimony to the abundance and variety of the Palæozoic Gymnosperms is obtained from the numerous fruits that have been discovered, in a single locality in the centre of France. The large series of fruits found there by M. Grand 'Eury have been described by Brongniart. He determined the occurrence of 26 species belonging to 17 genera, all of which have the fundamental structure of gymnospermous seeds, being orthotropous—that is, with the testa having the hilum and chalaza at the base and the micropyle at the apex, and enclosing an erect ovule, whose summit corresponds to the micropyle. But with this uniformity in essentials there is such diversity in characters of less importance, that a large number of species and genera had to be established for their reception. They all belong to the Taxineous group of Conifers, unless,

FIG. 5.

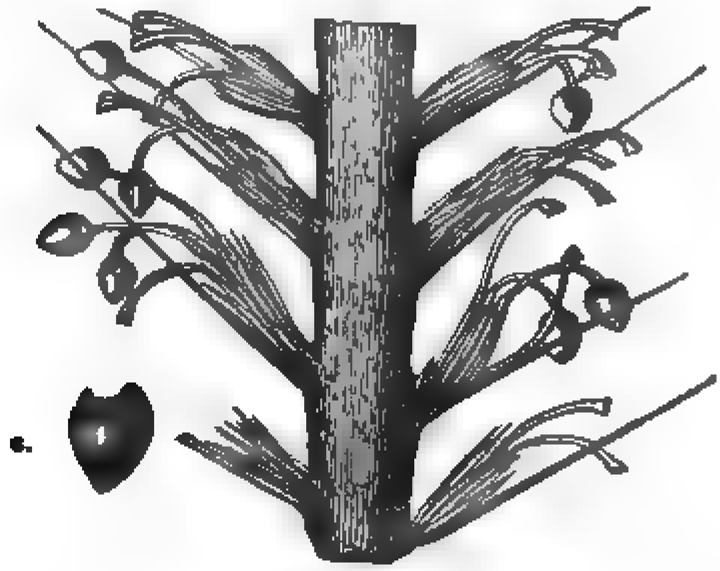


FIG. 5.—Portion of the Spike of *Cardiocarpum anomalum*, a gymnospermous plant from Coalbrookdale; c. a detached seed slightly magnified.

perhaps, some may be Cycadeæ. No fruits that can be referred to Abietineæ or Cupressineæ have been observed in Devonian or Carboniferous strata. On their first known appearance, then, the Gynosperms do not represent a generalised type, but both the wood and the fruits represent a remarkable variety of genera and species all as highly differentiated as existing forms.

In connection with this remarkable development of Taxineous Conifers at their first appearance, it should be noticed that the plants of this section are all diœcious, *i.e.*, have the sexes on different plants, while the other Conifers are generally monœcious.

The importance of this consideration will appear if we reflect that the production of spores from the contents of a single cell indicates the low position of the *Protophyta*, while the existence of sperm and germ elements in different cells is evidence of higher development among the cellular plants. If the occurrence of the germ and sperm elements in different flowers, and even in different individuals, is evidence, as some hold, of higher development in phanerogams, then it is important to notice the order of appearance of diœcious and monœcious groups in relation to those with hermaphrodite flowers. Advocates of evolution have maintained that dimorphic plants are now in a transition stage, progressing towards a diœcious condition. But if this view be held, the Conifers attained to the highest known development as regard this element of their structure on their first known appearance. The Abietineæ and Cupressineæ are not met with till the Permian and later periods.

The history of Monocotyledons, as far as it is known, is very curious; but as the earlier traces of these plants are very fragmentary, and their positions, consequently, doubtful, it is unnecessary to refer to them at any length. The first true Monocotyledon is the stem and spike of an Aroideous plant, of which a well-preserved specimen was discovered by Dr. Paterson about forty years ago in the lowest Carboniferous strata near Edinburgh.

FIG. 6.

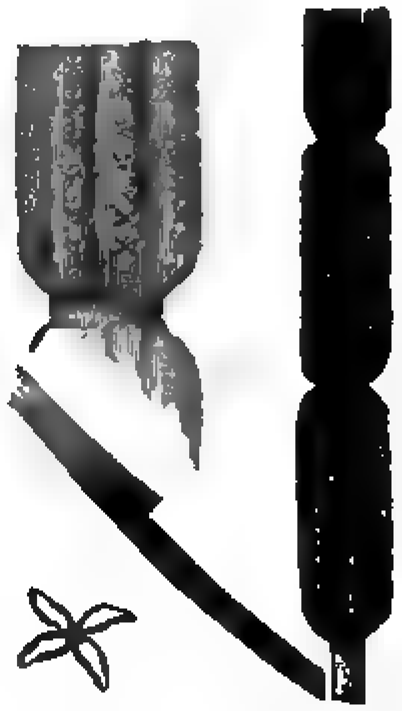


FIG. 6.—*Pothocites Grantoni*. The flowering spike of an Aroideous plant from the Calciferous-sandstone series near Edinburgh. *a*. A portion of the spike natural size; *b*. a smaller portion magnified; and *c*. a whorl of floral leaves more magnified.

Additional specimens have been recently found. The fossils which still figure in books under such names as *Cyperites*, *Culmites*, &c., are parts of cryptogamic plants; but the curious twisted bodies called *Spirangium*, believed to be Monocotyledonous fruits, make their first appearance in the Coal Measures. There are several species of *Spirangium*, as well as specimens of an allied, but yet undescribed genus in Carboniferous strata. Including these fruits, there are probably eight species of Monocotyledons in the later Palæozoic rocks. Four species have been found in the Trias, seven in the Lias, the same number in the Oolite, 15 in the Chalk, 97 in the Eocene, 185 in the Miocene, and two in the Pliocene.

According, then, to our present knowledge, the three groups of Vascular Cryptogams and the seed-bearing Gymnosperms appear together in the Devonian rocks, and Monocotyledons appear in the lowest beds of the Carboniferous series. Further, these earliest plants are not generalised forms of the various tribes to which they belong, but they are as highly specialised as any subsequent representatives of the particular group, and wherever they differ from later plants it is in the possession of a more perfect organisation.

It would be contrary to the evolution hypothesis to suppose that the highly-organised Cryptogams, the Gymnosperms, and the Monocotyledons were each evolved at one step from the cellular plants which form the only known vegetation of the Pre-Devonian periods. This would be as fatal to the hypothesis as the introduction of a supernatural Creator to place these groups at once on the earth in their complete development. "The theory of descent requires that the various forms of plants must have arisen at different times, that the primitive forms of the separate classes and groups existed at an earlier period than the derived ones."

No doubt there is in the older Palæozoic rocks a great absence of any records of land life. But the evolution of the Vascular Cryptogams and the Phanerogams from the green seaweeds through the liverworts and mosses, if it took place, must have been carried on through a long succession of ages, and by an innumerable series of gradually advancing steps; and yet we find not a single trace either of the early water forms or of the later and still more numerous dry-land forms. The condition that permitted the preservation of the fucoids in the Llandovery rocks at Malvern, and of similar cellular organisms elsewhere, were, at least, fitted to preserve some record of the necessarily rich floras,

if they had existed, which, through immense ages, led by minute steps to the Conifer and Monocotyledon of these Palæozoic rocks.

The complete absence of such forms, and the sudden and contemporaneous appearance of highly organised and widely separated groups, deprive the hypothesis of genetic evolution of any countenance from the plant record of these ancient rocks. The whole evidence is against evolution, and there is none in favour of it.

To complete the history of the vegetable kingdom, there yet remains for consideration the higher or Dicotyledonous division of flowering plants. Their testimony for or against evolution is the more important, because—first, of their higher organisation, by

FIG. 7.

FIG. 8

FIGS. 7 and 8.—Diœcious Flowers of the Willow. 1. Male Catkin; 1a. Single Apetalous Flower. 2. French Catkin; 2a. Single Apetalous Flower.

which, as regards their vegetative organs, they are sharply separated from the Monocotyledons, and, as regards both vegetative and reproductive organs, from the Gymnosperms; secondly, from the existence of numerous differences which supply generally obvious and well-defined characters for their systematic classification; and, thirdly, from their appearance in strata of comparatively recent age, which are consequently better known than Palæozoic deposits.

Dicotyledons are usually divided into three great groups, from characters derived from the structure of their flowers. 1. The Apetalæ, in which the corolla, and often the calyx as well, are absent. 2. The Monopetalæ, in which the calyx and corolla are present, but the petals are more or less united into a lobed corolla. And 3. The Polypetalæ, in which the calyx and corolla are also present, but the petals are free.

The phylogenesis of these groups is very circumstantially given by Hæckel. In the lower Dicotyledons, as in the case of the Monocotyledons, calyx and corolla are as yet not differentiated; hence they are called *Apetalæ*. This sub-class must, therefore, doubtless be looked upon as the original group of the Angiosperms, and it existed, probably, even during the Triassic and Jurassic periods. It was not till the Cretaceous period that the second and more perfect class of the Dicotyledons appeared—namely, the group with corollas. These arose out of the *Apetalæ*, from the simple cover of the flowers of the latter becoming differentiated into calyx and

FIG. 9.

FIG. 10.

FIG. 9.—The Polypetalous Flowers of the Pink.
FIG. 10.—The Monopetalous Flower of the Tobacco.

corolla. This group is again divided into two legions — the *Polypetalæ*, in which the flower leaves remain separate, and the *Monopetalæ*, in which the flower leaves grow regularly together into a more or less bell-like, funnel-shaped, or tubular flower. In these last the differentiation and perfection of the Phanerogamic flowers attain their highest stage of development, and we must, therefore, place them at the head of the vegetable kingdom as the most perfect of all plants.

Thus far, Hæckel,—what is the record preserved in the rocks? Dicotyledons make their appearance in strata of Upper Cretaceous age. No trace of a plant belonging to this great division has yet been detected in any earlier stratum. There is no evidence whatever for the statement that the Apetalæ probably existed in the Triassic and Jurassic periods. May not, however, the want of evidence be owing to the imperfection of the geological record? This imperfection would be due either to the absence of plant-remains from the strata which were formed when, according to this hypothesis, Dicotyledons existed in abundance, or to something in the nature of Dicotyledonous plants which prevented their preservation. But we are acquainted with a considerable Keuper Flora, consisting of Equisetums, Ferns, Cycads, and Conifers; a more extensive and similarly constituted Lias Flora, with the addition of cellular plants and some Monocotyledons. Plant-remains are necessarily rare in the marine beds of the Middle and Lower Oolites, but in the Upper division of this epoch we have an abundant Flora in Yorkshire, Sweden, France, and elsewhere, consisting of cellular plants and Monocotyledons, but chiefly of Vascular Cryptogams and Gymnosperms. In the Wealden, and even in the Neocomian or Lower Cretaceous strata, we find considerable Floras of Cellular and Vascular Cryptogams and Gymnosperms. These Floras are preserved in fresh-water deposits, some of them in the very localities where they lived, but in none of them has any trace of a Dicotyledon been detected. Their absence may, however, be supposed to be accounted for by the more speedy decay of the leaves of Dicotyledons demonstrated by the interesting experiments instituted by Lindley in 1833. But it is remarkable that, excepting Ferns and Gymnosperms, he found that a larger proportion of Apetalous plants resisted decay than any other group. It cannot be doubted that the conditions favourable to the preservation of Monocotyledons and Equisetums would have secured

the preservation of some of the Apetalæ, had they existed. This absence can be accounted for only on the supposition that they formed no part of the then existing vegetation. And in the deposits older than the Trias, or in any subsequent deposits, no intermediate form has been detected—no Gymnosperm or Monocotyledon which exhibits in any point of its structure a modification towards the more highly organised Dicotyledon.

Further, when the Dicotyledons appear in the Upper Cretaceous beds, representatives of the three great groups are found together in the same deposit. Moreover, these divisions are represented, not by generalised types, but by differentiated forms, which, during the intervening epochs, have not developed even into higher generic groups. Thus among the APETALÆ the *Myricaceæ* are represented by two congeners of our bog myrtle; the *Cupuliferæ* by six species of oak and beech; the *Salicineæ* by six species of willow and nine of poplar; the *Moreæ* by six species of fig; and the *Laurineæ* by a laurel and six species of a *Sassafras*. Among the MONOPETALÆ the *Asclepiadeæ* are represented by a species of *Nerium*; the *Ebenaceæ* by a *Diospyros*; and the *Ericaceæ* by an *Andromeda*, And among the POLYPETALÆ, the *Araliaceæ* are represented by a species of *Aralia*; the *Anacardiaceæ* by a *Rhus*; the *Sapindaceæ* by a maple; and the *Magnoliaceæ* by five species of *Magnolia* and two of the tulip tree.

While the rocks supply no evidence of any plant leading up to these various orders of Dicotyledons, it is equally important in its bearing on the hypothesis of genetic evolution that the generic groups just named have persisted from the first known appearance of Dicotyledons throughout the whole of the intervening ages, and still hold their places unchanged among the existing forms of vegetation. The persistence of generic and specific types, and the certain knowledge we possess of the life of many existing species of Phanerogams and Cryptogams which have come down through the Glacial Epoch, have not been sufficiently considered in their bearing on this hypothesis.

Let us take a case. None can be more fitted for this purpose than the small willow, *Salix polaris*, detected in the lowest pre-Glacial beds at Cromer, and in deposits of the same age at Bovey Tracey. This plant still lives in the Arctic regions of both the Old World and the New.

The genus *Salix* is a singularly variable one, and should supply satisfactory data for an evolutionist working out his hypothesis. According to Professor Andersson's latest Monograph of the Order (Dr. Candolle's "Prodromus," Vol. xvi., pt. 2), the genus *Salix* consists of 19 sub-generic groups, containing 160 species, and these are so variable that 222 varieties and 70 hybrids have been described and named by him. It is a genus, then, which is from the point of view of the evolutionist, at present actively moving on to a large addition to its species by the increase and persistency of the numerous varietal forms. The sub-generic groups to which *Salix polaris* belongs contain 29 species, together with 26 varieties and 9 hybrids. These are further arranged into four sections, that to which *Salix polaris* belongs containing six species. It is easy, then, to construct an exact phylogenetic tree of the genus *Salix*. The hybrids and varieties, amounting to an average of about two for each species, lead up to the recognised species. The various species converge to the parent form of the section to which they belong. The generalised sectional forms, in their turn, approach each other, and unite in the parent form of the sub-generic group. The 17 sub-generic forms gradually approach each other, until the generalised type of the genus *Salix* is reached. The shortest branches in this phylogenetic tree are necessarily the ultimate twigs which represent the evolution of the varieties from the species; but in the case of *Salix polaris* no varietal forms are known, notwithstanding the specially favourable circumstances in the history of this plant for their production, for this species has, by stress of weather, been driven, throughout the ages that intervene between the deposition of the pre-Glacial beds of Cromer and our own days, from Devonshire and Lincolnshire into the extreme northern regions; yet it has through all these vicissitudes remained unchanged. The ultimate twig in this species is that which represents its own specific life, and this must be a short twig when compared with the branches leading the six allied species to the section or those leading the section to the sub-genera, or the branches leading the sub-genera up to the genus. Yet this ultimate twig takes us back to pre-Glacial times; it covers the ages represented by the Glacial Period and its associated deposits, by the later fossiliferous deposits at Bridlington and in the valleys of the Forth and Clyde, and the subsequent period during which man has been on the earth.

But when we have reached the branch representing the generic form, we have made but little progress in the phylogenesis of *Salix*. With *Populus* this genus forms a small Order, Salicineæ. The two genera are closely allied, yet separated by well-marked characters; it is not, however, difficult to conceive of both having sprung from a generalised form. But there is no record of such a form. The two genera appear together among the earliest known Dicotyledons, the willows being represented by six and the poplars by nine species. The ordinal form, if it ever existed, must necessarily be much older than the period of the Upper Cretaceous rocks, that is than the period to which the earliest known Dicotyledons belong.

The Salicineæ are related to five other natural Orders, in all of which the apetalous flowers are arranged in catkins. These different though allied Orders must be led up by small modifications to a generalised amentiferous type, and thereafter the various groups of apetalous plants by innumerable eliminations of differentiating characters until the primitive form of the apetalous plant is reached. Beyond this the uncurbed imagination will have more active work in bridging over the gap between Angiosperms and Gymnosperms, in finding the intermediate forms that led up to the Vascular Cryptogams, and on through the cellular plants to the primordial germ. Every step in this phylogenetic tree must be imagined. The earliest Dicotyledon takes us not a step further back in the phylogenetic history of *Salix* than that supplied by existing vegetation. All beyond the testimony of our living Willows is pure imagination, unsupported by a single fact. So that here, also, the evidence is against evolution, and there is none in favour of it.

The demand upon time made by the advocate of genetic evolution is a further serious difficulty. The single species *Salix polaris* carries us back beyond the Glacial Period. Several specific forms existed, as we have seen, during the Cretaceous epoch. Beyond this, we want geological periods, which are the geologists' time divisions, to carry back, by slow and imperceptible changes, the Cretaceous *Salices* and the rich associated flora of still existing generic types to the generalised Angiosperm and on to the Gymnosperm.

The whole evidence supplied by fossil plants is, then, opposed to the hypothesis of genetic evolution, and especially the sudden and

simultaneous appearance of the most highly organised plants at particular stages in the past history of the globe, and the entire absence among fossil plants of any forms intermediate between existing classes or families. The facts of palæontological botany are opposed to evolution, but they testify to development, to progression from lower to higher types. The Cellular Algæ preceded the Vascular Cryptogams and the Gymnosperms of the newer Palæozoic rocks, and these were speedily followed by Monocotyledons, and, at a much later period, by Dicotyledons. But the earliest representatives of these various sections of the vegetable kingdom were not generalised forms, but as highly organised as recent forms and in many cases more highly organised; and the divisions were as clearly bounded in their essential characters, and as decidedly separated from each other, as they are at the present day. Development is not the property of the evolutionist; indeed, the Mosaic narrative—the oldest scheme of creation—which traces all nature to a supernatural Creator represents the operations of that Creator as having been carried out in a series of developments, from the calling of matter into existence, through the various stages of its preparation for life, and on through various steps in the organic world, until man himself is reached. The real question is,—Does science give us any light as to *how* this development was accomplished? Is it possible, from the record of organic life preserved in the sedimentary deposits, to discover the method or agent through the action of which the new forms appeared on the globe? The rocks record the existence of the plants and animal forms; but as yet they have disclosed nothing whatever as to *how* these forms originated.

ORDINARY MEETING, November 3rd, 1876.

William Carruthers, Esq., F.R.S., &c., President, in the Chair.

The following Donations were announced:—

"Recherches sur le terrain Crétacé Supérieur de l'Angleterre et de l'Irlande," by Charles Barrois, D.Sc.; from the Author.

"Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country," by F. B. Meek; from Dr. F. V. Hayden.

"Monograph of the Geometrid Moths or Phalænidæ of the United States," by A. S. Packard, Jun., M.D.; from Dr. F. V. Hayden.

"On the Occurrence of the Rhœtic Beds in Leicestershire," by W. J. Harrison, F.G.S.; from the Author.

"On the Triassic Strata exposed in the Cliff-Sections near Sidmouth," by H. J. Johnston-Lavis, F.G.S.; from the Author.

"Quarterly Journal of the Geological Society," Vol. xxxii., Part 3; from that Society.

"Abstracts of the Proceedings of the Geological Society," No. 322; from that Society.

"Journal of the Society of Arts," July to October, 1876; from that Society.

"Journal of the Quekett Microscopical Club," No. 32; from that Club.

"Proceedings of the West London Scientific Association and Field Club," Vol. i., Part 3; from that Association.

"Transactions of the Watford Natural History Society and Hertfordshire Field Club," Vol. i., Part 5; from that Society.

"Proceedings of the Somersetshire Archæological and Natural History Society," New Series, Vol. i., Part 1; from that Society.

"Proceedings of the South Wales Institute of Engineers," Vol. ix., No. 5, and Vol. x., No. 1; from that Institute.

"Transactions of the Royal Irish Academy," Vol. xxvi. (Science), Parts 1-5; from that Academy.

"Proceedings of the Royal Irish Academy," Series 2, Vol. ii., Nos. 4, 5, and 6 (Science); from that Academy.

"Annual Report of the Leeds Philosophical and Literary Society," for 1875-76; from that Society.

"Annual Report of the Leeds Naturalists' Club and Scientific Association," for 1875-6, and "Constitution of the Club;" from that Club.

"Annual Report of the Yorkshire Philosophical Society" for 1875; from that Society.

"Annual Report of the Warwickshire Natural History and Archæological Society," for 1875-6; from that Society.

"Bulletin of the United States Geological and Geographical Survey of the Territories," Vol. ii., Nos. 3 and 4; from Dr. F. V. Hayden.

The following were elected Members of the Association :—

Alfred Craven, Esq.; John W. Meyers, Esq.; Charles Reginald Parkes, Esq.; and H. Sidney White, Esq.

The President delivered the Opening Address of the Session 1876-77. (See page 17.)

ORDINARY MEETING, DECEMBER 1ST, 1876.

WILLIAM CARRUTHERS, Esq., F.R.S., &c., President, in the Chair.

The following Donations were announced :—

"Quarterly Journal of the Geological Society," Vol. xxxii., Part 4; from that Society.

"Abstracts of the Proceedings of the Geological Society," No. 233; from that Society.

"List of the Geological Society," November, 1876; from that Society.

"Proceedings of the Literary and Philosophical Society of Liverpool," Vol. xxx.; from that Society.

"Journal of Proceedings of the Winchester and Hampshire Scientific and Literary Society," Vol. ii., Part 2; from that Society.

"Transactions of the Manchester Geological Society," Vol. xiv., Parts 4-5; from the Society.

"Annual Report of the Royal Cornwall Polytechnic Society" for 1875; from that Society.

"Leicester Town Museum—First to Fourth Reports of the Museum Committee to the Town Council" (1873-76); from that Committee.

"President's Addresses and Reports of the Leicester Literary and Philosophical Society," 1867-72; from that Society.

"Reports of the Leicester Literary and Philosophical Society," for 1874-5, and 1875-6; from that Society.

"Transactions of the Leicester Literary and Philosophical Society," Part 1 (1835-38) and Part 2 (1838-41); from that Society.

"Education and Culture: Address delivered to the Leicester Literary and Philosophical Society, 1876," by the Rev. A. Mackennel, President; from that Society.

"Journal of the Society of Arts," November, 1876; from that Society.

"Note on the Pleistocene Deposits at Crayford and Erith," by Messrs Cheadle and Woodward; from the Authors.

"L'Age de la Pierre de Totternhoe," by Dr. Charles Barrois; from the Author.

"Le Gault dans le bassin de Paris," by Dr. C. Barrois; from the Author.

"Taylor's Calendar of the Meetings of the Scientific Bodies of London for 1876-7;" from Messrs. Taylor and Francis.

The following were elected Members of the Association:—

William I. Balston, Esq., F.G.S.; Oliver Daniel Belsham, Esq.; Alexander Bessemer, Esq., B.A.; Robert Harland, Esq., F.C.S.; Alfred Spalding Harvey, Esq., B.A.; Colonel John Davenport Shakespear, F.G.S., Assoc. Inst. C.E.; Arthur I. Walmisley, Esq., Assoc. Inst. C.E.; and John Johnston Winser, Esq.

The following Paper was read:—

On the Comparative Ages of the English and Scottish Coal Fields, illustrated by the Geology of the Lothians and Fife, and the Structure of Arthur's Seat.

By Andrew Taylor, Esq., F.C.S.

The natural sections in and around Edinburgh rendered classic by the descriptions of Hutton and Playfair, must always incite a more than local interest. Arran is the only other Scottish locality offering such a succession of field studies within a very narrow area. Professor Judd has recently invited renewed attention to the structure of Arthur's Seat, showing that past labours only suggest more difficult and, therefore, more interesting inquiries. I venture to describe some local sections at some distance from the hill itself; because of their bearing on the question thus raised as to the chronology of the eruptions of Arthur's Seat.

Salisbury Crags, perhaps, most distinctly of the many sections in the Edinburgh Queen's Park, afforded the Wernerians pegs for ventilating their peculiar theories. Indeed, the petrological peculiarities of many of the traps there as well as round Edinburgh favour the idea of their metamorphism. The presence of prehnite, pectolite, analcime, chalcedony, and allied minerals

surely testifies of the past agency of thermal springs, while St. Bernard's hot well and the petroleum spring of St. Catherine's are their existing representatives. I simply recall, while not advocating Delesse's idea of the metamorphism of such Irish traps as those of the Giant's Causeway; and of Bunsen's derivation of all traps from one or two Icelandic tuffs. But the occurrence of datholite in Salisbury Crags, as well as of fluorine in many of the neighbouring traps, bespeaks a divided verdict. On merely chemical grounds, we must assume that directly igneous as well as hydro-thermal agencies have been at work. I allude to the subject because of Boüe's section of Arthur's Seat; in which a flat bed of basalt rests horizontally on the summit, with no plugged pipe going downwards as in all subsequent ones. The summit, according to Wernerian reasoning, may have been part of a neighbouring stratified trap, isolated into its present form, *partly* by contraction and weathering. Should the tendency to derive traps, perhaps from sedimentary strata, by metamorphism, at present being revived by some petrologists, yield tangible fruit, this old theory in some modified shape may again appear in discussion on the chronology of this hill. It need not then be entirely dismissed from court.

Charles Maclaren originated the idea of the plug running downwards from the summit; popularised by Sir James Richardson's comparison of the hill to a wine decanter with its stopper. Maclaren also propounded the theory of the hill being formed during at least two eruptions at widely different intervals of geological time. All this has been amplified by Professor Geikie, who has called in the aid of an additional plug in his published sections, to originate the basalt of the Lion's Haunch; and who has postulated the time of the last eruption to have been in the Tertiary period; subsequently, however, affixing it to the earlier Permian epoch. Professor Judd has recently taken exception to both of these major propositions; and shows that Maclaren latterly gave up the idea of two eruptions. He suggests that the basalt of the Lion's Haunch proceeded from a vent above it now blown away; and that it fills a fissure in the agglomerate caused by shrinkage; questioning, at the same time, the evidence for a second eruption, said to be shown in the uncomformable overlap of the agglomerate on the highly inclined strata seen on the Queen's Drive east of Samson's Ribs. Maclaren further postu-

lated a covering of the whole ground round Edinburgh and westward by the junction of the Dalkeith and Falkirk coal-fields; and this is homologated by the other two authors referred to, who, whilst differing as to the fact of a second eruption, both agree that the present physiography of the surrounding country was caused by denudation of perhaps three thousand feet of strata. If such can be made out, this is a local geological wonder greater than any of the surrounding monuments of the power of vulcanism. The conception is a grand one—but is it true?

Our notions respecting the stratigraphical geology of the surroundings of Arthur's Seat have altered since Maclaren's day. The district boundaries, the hill-chains of the scenic panorama, still demonstrate the dependence of landscape features on geological structure. The far-off Lamermoors and Moorfoots to the south-east speak of the boundary line of the Scottish coal-fields stretching from St. Abb's head to Ayrshire. The nearer Pentlands have yielded abundant Silurian fossils, and thus tell us how the Coal Measures began to be formed when they had been elevated from the sea bottom; while the higher ranges which bound the northern edges of the Fife coal-basins testify that Lowland Scotland existed as a fiord, surrounded as now by its bounding ranges of the northern and southern highlands, when its coal-beds were being formed. But if the valley ultimately grew to a height of three thousand feet, must not these ranges have been higher than now? Perhaps a study of the warpings and puckerings of both these northern and southern boundary chains from a mathematical point of view will bring this out. Thus, too, a fixed gathering ground for glaciers, whether in the Palæozoic ages or subsequently, may be discovered.

Maclaren's assumed denudation of Arthur's Seat after the first eruption takes for granted the contemporaneous age of the English and Scottish coal-fields. But, in geology as well as botany, easy systematising may hide scientific truth. The Upper Old Red Sandstone beds are now found to run into the Lower Carboniferous ones throughout Scotland. Both exhibit either lacustrine, fluviatile, or estuarine characters. The Burdiehouse-limestone bed, long recognised as the estuarine horizon bed of the Lower Carboniferous strata, has been discovered near the Windy Goul, on the hill itself, as well as in deep drains at Rankeiller Street in its vicinity, capped by shale; and at Loch End, which some take

to be the natural prolongation of Salisbury Crags. The line of outcrop with the horizon at Burdiehouse stretching above Craigmillar Castle towards Portobello forms a distinct scenic feature. So, too, does the upper line of the Gilmerton Marine-limestone, on which abuts the highly inclined Niddrie coal and ironstone beds. Professor Geikie, in a newly-issued geological map of Scotland, colours the space betwixt Liberton and the hill as Upper Old Red, making the patch stretch inwards to the Pentlands above Colinton. I am inclined to dispute this; but it does not hinder my argument if, with Salter, we regard the Upper Old Red and Lower Carboniferous as one and the same formation. The Upper Marine-limestones, we know, indicate the only palæontological differences betwixt the Lower and Upper Scottish Carboniferous beds. The absence of marine forms is indeed the only characteristic features of these Upper beds. Now, do we well to infer that the presence of marine organisms alone demands such an oscillation of the land, as to change estuarine into such marine conditions as are typified by the coral reefs of the Pacific? If this be a generalisation founded on imperfect knowledge of living conditions, then many of the boundary lines of our geological maps are arbitrary. Professor Hart found corals of genera and species we were wont to associate only with the deep sea, flourishing at the mouths of the great Brazilian rivers. Now the central Scottish valley is readily comparable to such existing estuaries. And it is easy to imagine a series of subsidences and upheavals resulting in the formation of the coals, ironstones, and shales, which alternate with the thin beds of marine limestone below the true Coal Measures, and which are usually four to five feet thick, not a mountain mass a thousand feet thick, as in England. Professor Young, in describing the western series, says* :—"The absence of all sign of oscillation in the English area, even in Northumberland, proves the entire distinctness of the Scottish formations, and seems to forbid the supposition that the Carboniferous Limestone sea had been a continuous one from the Grampians to the Midland Counties; and to point to the existence of a barrier in the position of the southern uplands. The English limestone series was in all probability contemporaneous with, not the so-named series in Scotland, but with all the deposits from the Upper Old Red, and perhaps part even of that." While the Northumberland bed was forming,

* "The Geology and Palæontology of the West of Scotland," p. 12.

according to Professor Hull, a different condition of things prevailed in the Bristol Carboniferous area. Whether, as we understand this authority holds, some of the Irish coal-fields, show most affinity with the Scottish ones, and the floras both show striking resemblances with Stuhr's Culm Flora of Bohemia, it appears dangerous to write a history of the Scottish Carboniferous system from data taken from the geological map of England. The total thickness of the Lancashire coal-fields is about 12,200 feet; that of the Lothians only 6,400 feet. Neither is there such a similarity between the beds of the several Scottish coal-fields as to admit of comparing them as a whole either with their local equivalents or with those in England. I refer to Professor Young's paper already quoted for details as to the western coal-fields. Thus the Geological Survey discovered that at Douglas the Coal Measures proper rest almost directly on the Silurian rocks; the intervening series of strata being omitted. The sub-divisions of the Carboniferous System, as given in the generalised vertical sections of the text-books, are delineated on the survey maps. But, in this respect, are they true to nature? "The Roslyn Sandstone of Mid-Lothian,"* says Professor Young, "is represented by a mass of sandstones, in which, however, fire-clays, clay-ironstones, and limestones attest conditions quite distinct from those of the Millstone Grit of England. The few fossils obtained from them are limestone species. It is doubtful if the identification of the group has better ground than a desire to harmonise the Scottish and English systematic tables. This group of strata thins away westward from the Mid-Lothians, where it is of minor importance as compared with its English equivalent, and is no longer recognisable in Ayrshire." Practical as well as scientific men are now fully aware of the danger of trying to find bed for bed in widely different localities of our Scottish Carboniferous rocks. This is partly owing to the thinness of the beds as compared with those of England; hence the different modes of winning coal practised in the two countries, and also from being formed under different physico-geographic conditions.

The distance eastward from Arthur's Seat to the outcrop of the Marine-limestone at Gilmerton is only about three miles. We have to traverse eighteen miles westward ere we come to the correspond-

* Op. cit., p. xiv.

ing bed in the Bathgate Hills. Again, we can walk betwixt the Burdiehouse outcrop and that of Gilmerton in less than a mile, On the other hand, the whole westward area just indicated is occupied by the Oil-shale series, at the base of which is a bed or beds corresponding to the estuarine one just mentioned. Those westerly strata are broken up into a series of small basins, in some of which the lower members only are brought to the surface; apparently preserved from entire denudation by the surrounding trap bosses which usually jam in the edges of the basin. Bores from the surface in other parts pierce through the complete series, as shown in the section to be described. Step-faulting, aided by lateral compression, has apparently produced this state of things. Abundant physical proofs evidence a state of intense vulcanism when the strata were being deposited, as well as, perhaps, of movements equally affecting the whole upper Scottish strata. The traces of hydrothermal action abound throughout this district, as well as in the Arthur's Seat group. The petrologist may find here a most interesting field of study.* There are abundant materials, at least, for question as to the general propositions that all limestones and coals are of organic origin. Professor Ramsay has recently suggested that the Burdiehouse-limestone may have been due in great part to hydrothermal agency. Other limestones, such as the Kirkton at Bathgate, which contains estuario-marine fossils, show this even more evidently. The limestone above it, containing corals, *Productus*, and other marine fossils is 60 feet, and of a beautiful white crystalline appearance. Curiously enough, this very bed, a few miles westward, though also fossiliferous, is only four feet thick. Hydrothermal agency, rather than oscillation of level, appears the most likely explanation. Dr. Hayden describes a bed on the Yellow-stone region of North America, which, *pari passu*, may apply to the Bathgate one. "On the summits of mountains 1,500 to 2,000 feet above the river, and having evidently been lifted up by the forces that elevated the whole range, is a bed in thickness 50 to 150 feet; very hard, white and yellowish-white—so hard as to make excellent building material and the whitest of lime. This has probably got its extra thickness, as seen on the hills, from the fresh-water limestone below it." Many of the traps smell of bitumen, but it occurs, in its various forms, both in them and their

* For localities, see Hay Cunningham's "Prize Essay on the Geology of Fife and the Lothians:" Edin. James Thin.

according to Professor Hull, a different condition of things prevailed in the British Carboniferous area. Whether, as we understand this authority holds, some of the Irish coal-fields show most affinity with the Scottish ones, and the former both show striking resemblances with Stur's Culm Flora of Bohemia, it appears dangerous to write a history of the Scottish Carboniferous system from data taken from the geological map of England. The total thickness of the Lancashire coal-fields is about 12,000 feet; that of the Lothians only 6,400 feet. Neither is there such a similarity between the beds of the several Scottish coal-fields as to admit of comparing them as a whole either with their local equivalents or with those in England. I refer to Professor Young's paper already quoted for details as to the western coal-fields. Thus the Geological Survey discovered that at Douglas the Coal Measures proper rest almost directly on the Silurian rocks; the intervening series of strata being omitted. The sub-divisions of the Carboniferous System, as given in the generalised vertical sections of the text-books, are delineated on the survey maps. But, in this respect, are they true to nature? "The Roslyn Sandstone of Mid-Lothian,"* says Professor Young, "is represented by a mass of sandstones, in which, however, fire-clays, clay-ironstones, and limestones attest conditions quite distinct from those of the Millstone Grit of England. The few fossils obtained from them are limestone species. It is doubtful if [illegible]tification the group has better ground than a desire to h[illegible] the Scot and English systematic tables. This group [illegible]ins westward from the Mid-Lothians, where it is [illegible] as compared with its English equivalent, and [illegible] able in Ayrshire." Practical as well as sci[illegible] fully aware of the danger of trying to find [illegible] different localities of our Scottish Carbonifer[illegible] partly owing to the thinness of the [illegible] as co[illegible] of England; hence the different n[illegible] in the two countries, and also fro[illegible] physico-geographic conditions.

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ing bed in the Bathgate Hills. Again, we can walk betwixt the Burdiehouse outcrop and that of Gilmerton in less than a mile, On the other hand, the whole westward area just indicated is occupied by the Oil-shale series, at the base of which is a bed or beds corresponding to the estuarine one just mentioned. These westerly strata are broken up into a series of small basins, in some of which the lower members only are brought to the surface; apparently preserved from entire denudation by the surrounding trap bosses which usually jam in the edges of the basin. Bores from the surface in other parts pierce through the complete series, as shown in the section to be described. Step-faulting, aided by lateral compression, has apparently produced this state of things. Abundant physical proofs evidence a state of intense vulcanism when the strata were being deposited, as well as, perhaps, of movements equally affecting the whole upper Scottish strata. The traces of hydrothermal action abound throughout this district, as well as in the Arthur's Seat group. The petrologist may find here a most interesting field of study.* There are abundant materials, at least, for question as to the general propositions that all limestones and coals are of organic origin. Professor Ramsay has recently suggested that the Burdiehouse-limestone may have been due in great part to hydrothermal agency. Other limestones, such as the Kirk- [illegible] Bathgate, which contains estuario-marine fossils, show this [illegible] evidently. The limestone above it, containing corals, [illegible] and other marine fossils is 60 feet, and of a beautiful [illegible] ance. Curiously enough, this very bed, a [illegible] h also fossiliferous, is only four feet thick. [illegible] her than oscillation of level, appears [illegible] Dr. Hayden describes a bed on the [illegible] h America, which, *pari passu*, may [illegible] On the summits of mountains 1,500 [illegible] d having evidently been lifted up [illegible] hole range, is a bed in thickness [illegible] and yellowish-white—so hard as [illegible] l and the whitest of lime. This [illegible] s, as seen on the hills, from the [illegible] Many of the traps smell of [illegible] forms, both in them and their

* Prize Essay on the Geology of

associated strata; thus suggesting the problems whether the oil-shales have not been formed by infiltration, and also if many of the trappean ridges may not have originated like the salzes, *e.g.*, of the Crimea, rather than as true volcanoes. The hydrocarbon vapours would have sufficient rending power to form most of the local dislocations.

The first section I call attention to may be studied by the English traveller coming to Edinburgh by the Caledonian Railway. Within eighteen miles of the grey northern metropolis he passes Cobbinshaw Loch, an artificial reservoir, made to feed the Union Canal. The swelling slopes of the Pentland ranges bound the south-western horizon, while on the north ridgy green hills, whose else uniform summits are diversified by sharp peaks, mark the ontake of the Lanarkshire Coal Measures on the Marine-limestone. This—a thin bed with coal beneath it—crops out at the little station near this summit-level, and the train runs down a sharp descent to Kirknewton, where the Burdiehouse-limestone crops out. Betwixt are a series of shales, ironstones, sandstones, and thin beds of coal. As the train descends this Lower Carboniferous section the Pentlands increase in height. They are about 1,200 feet near Cobbinshaw, and above 2,000 feet high near Edinburgh. But from the northern windows of the railway carriage the tourist now views a landscape very different from that just passed. The broad swelling Forth and the distant Ochils, with the Lothians and Fife green in wooded hill or rich pastures, among interspersed highly cultivated corn-fields, gladden the eye so long accustomed to an unvaried monotony of bog and moor. The physiography of this beautiful isometric panorama is conspicuous. The Bathgate Hills to the north-west are the prominent scenic feature, while in the interval dividing them from the railway long narrow valleys stretch, one of them containing the course of the river Almond in a W.N.W. and E.S.E. direction. This line of fissure may, indeed, be traced by the igneous protuberances crossing through Fife. The encircling Queensferry and Burntisland hills seem to lend a fit setting to the varied landscape. All the separate hills betwixt them and Arthur's Seat, not excluding the fantastic Binny Crag at the eastern extremity of the Bathgate range, exhibit evidences of similar age, for they bring up the Burdiehouse-limestone with some of its associated beds in their structure. So their study bears on our special

problem. One of my sections is right through this landscape, from East Calder to the Bathgate Hills; the other is taken at North Queensferry at its northern extremity.

The first section stretches from the Camp's Quarries at East Calder to Kirkton on the Bathgate Hills. Mining engineers—I think with reason—take this latter bed, so much altered there by thermal springs, to be the same as that found at Addiewell and Blackburn with a bed of coal below it. It deals with the accompanying succession of strata, having a total thickness of upwards of 1,700 feet, which latter number is also about the height of the point above Cobbinshaw, where the Upper Coal Measures come on. This is also about the greatest height of the Bathgate Hills, Arthur's Seat being 800 feet above the sea-level.

Succession of the Oil-bearing shales of the West Calder district.

	Thickness.	
	Feet.	Inches.
Main Limestone	6	0
Coal below the Limestone	5	6
Intervening strata of Sandstones, &c., 12 fathoms.		
Two-feet Coal, averaging	1	10
Intervening strata of Blaes and Sandstone Ribs, 80 fathoms.		
Dam or Raeburn's Shale	2	6
Intervening strata of Blaes and Ironstone Ribs, 18 fathoms.		
Mungles, Shale, or Curly	1	6
Intervening strata of Blaes and Sandstone, 35 fathoms.		
The two-feet (Houston Coal)	1	10
Strata of Marl, or Ash-beds, 30 fathoms.		
The Grey Shale, average	1	8
Strata of Sandstone and Fakes, 11 fathoms.		
The Houston Main Coal	5	6
Fireclay, Sandstone, and Blaes, 32 fathoms.		
The thick Shale, average	2	8
Limestone Ribs and Blaes, 5 fathoms.		
The Burdiehouse Limestone in Ribs	11	0
Sandstone, Cement Ribs, and Blaes, 32 fathoms.		
The Broxburn Shale, average	3	3

Below this a succession of impure arenaceous and calcareous strata, in thin ribs, prevail. The richly bituminous oil-shales marked on this vertical section occur in thick beds of ordinary shale, and, according to Government surveyors, are not met with in the Lower Carboniferous series to the south of Carstairs.

To revert to the longitudinal section. At Drumcross the highest marl or stratified ash crops to the surface; so here alone fully 750 feet of the surface must have been planed off. Ere that,

the Bathgate Hills must have had double their present height. Volcanic emissions must have gone on long after the first marine limestone terminating our diagram was deposited, up through the series of gas-coals, coals, black-bands, and fire-clays, betwixt this and the horizon of the third or Leaven Seat limestone. All this is testified by the stratified traps of the Boness coal-field, as well as by the Shotts and Craigs hills. Probably, too, when the Bathgate Hills had their ancient physical configuration the Torbane Hill bed was being formed. It occurs just beyond the outcrop of the highest Marine-limestone at Stand Hill, and thins off from three feet at the centre to a few inches at the outcrop of its local basin, which is only three miles in circumference. The trappean sheets filling the crevices of the basins in our section thus continued till the deposition of the Upper Coal Measures, probably sending out ferric oxide, which, coming in contact with the decaying organic matter in the shallow lagoons on the borders, would result in the formation of clay and black-band ironstones. The section, too, shows a lateral squeeze of the strata, diminishing them thus nearly in the proportion of their extreme height, when undenuded, between Bell's Quarry and Dechmont. This phenomenon also persists to the Upper Coal Measures. Thus the Upper Marine-limestone occurs both high up on the Bathgate Hills and at their base near Standhill at Young's old chemical works. Have we here repeated on the small scale the phenomena of inversion and subsequent downthrust so grandly displayed on the Himalayas? At Cobbinshaw no physical change indicates the alteration from marine to fresh-water fossils in these beds. When the cooling lava of the local volcanoes contracted, it would also bring down its associated sedimentary beds to a considerable depth. Moreover, limestones and clays, in some sort or other, are the prevailing rocks of this district. Limestone expands as cooling clay contracts. Are we not justified in taking this as the *vera causa* for some of the curious dislocations of our section of this sorely shaken district? The varied felspathic and augitic traps are amongst its marked features, and awaken the surmise that this cooling may have been gradual, for Phillips has shown how the felspathic lavas, from specific gravity and chemical constitution, could be cooled contracted masses when the doleritic ones were yet red-hot. But if most of the lateral trappean sheets were caused by the shrinkage of the aqueous strata, I think we are justified in

saying, so far as the present section is concerned, that they were emitted after the deposition of the highest Marine-limestone, being accompanied by the dislocation, contraction, and denudation of the land on which grew the forests now forming the Upper Lanarkshire Coal Measures.

The next section was made in cutting a tunnel through the North Queensferry Hills, which form a prominent scenic feature in the landscape looking north from Arthur's Seat. These Hills clearly mark out the junction of the narrower river with the bold estuary, and protect St. Margaret's Hope, often a sore-desired haven from fell north-easters to the weary mariner. The Ferry Hills are mostly composed of hornblendic greenstone or dolerite, which has long been quarried for harbour purposes. They afford many striking examples of the tendency of some trap-rocks to weather in an onion-like fashion, some of such concentric balls on the northern sea cliffs being of large diameter. The physiography of the hills exhibits two flattened prominences, gradually sloping at an angle to the north, but with abrupt escarpments towards the Ferry. The hill further from North Queensferry, which is being now quarried, has an escarpment affording splendid examples of columnar cleavage, and slopes up the other side, with a gentle dip, into Inverkeithing Bay. At the other extremity of the Dunfermline coal-field, above the town, we find trap-rocks associated with marine limestones, as at Bathgate. I am inclined, then, to associate the trappean rocks of this tunnel and around it as of the same geologic horizon with those first described.

The engineers let the excavation of this tunnel to the contractors on the understanding that they had to pierce through a uniform mass of trap. The hill, with its neighbour, is marked on the Geological Survey map with the crimson stain of intrusive dolerite. I do not know, but a careful attention to the rule laid down by the late Professor Fleming, that the softer aqueous rocks weather in a different manner from trap rocks capping them, might have induced other conclusions. At all events, the forecasts of the parties concerned in this work were not verified by actual experience. In the earlier months of the contractors' operations no aqueous rock was met with. It began to appear as if the hill were not really, after all, an intrusive dolerite, but that this latter bed lay interstratified with the sandstones. Only towards the

close of the work did a narrow plug, about sixty feet long, become visible, in which the aqueous strata were curved upwards and metamorphosed, while a thin neck of dolerite communicates with the overlying mass forming the hill. I am indebted to W. Wilson, Esq., of Dunfermline, the contractor, for detailed information and specimens.

The tunnel exhibits two step faults in its course. On its north side sandstone was cut through, while shale was pierced at its southern extremity. The beds cut through are, in ascending order, thus:—

3. Sandstone, once quarried at north side of tunnel.

2. Shale, or blaes, some of it oily, with thin banks of clay-band ironstone.

1. Burdiehouse-limestone.

These beds, which we have met with in our previous studies, may also be traced upwards along the shores of the Forth to Rosyth; whilst three miles farther north the Marine-limestone caps the Lower series at Limekilns. In the plug of the tunnel the limestone stood almost vertically, assuming a white crystalline character. Below it, a bed of ozokerite, three inches deep, occurred. Some of the shale in the plug had a rather columnar form, while close to the dolerite, the clay-band ironstone and shale appear to have metamorphosed into a unique mass possessing none of the distinctive characters of the two rocks.

On emerging from the tunnel, which is nearly a quarter of a mile long, the railway runs above shale and sandstone, with about the same dip as that prevailing on its northern open side. But where the new pier begins, an abrupt prominence marks a fresh outburst of dolerite. Just before high-water mark the bed of the river sinks at a steep angle to sixty or seventy fathoms, the greatest depth in the estuary; while three miles up, at Limekilns, the borers could find no practicable foundation for the Forth bridge in the sludge and sand abounding there, as here. These facts rather pertain to the domain of surface geology. But what if a portion, at least, of this denudation occurred in Scottish Carboniferous times? Looking eastwards from our present standpoint are the high Burntisland cliffs, the Forth islands of Inchcolm and Inchkeith, and on the east coast, the far-off Bass and Berwick Law, the nearer Arthur Seat, Dalmeny, and Mons Hills,

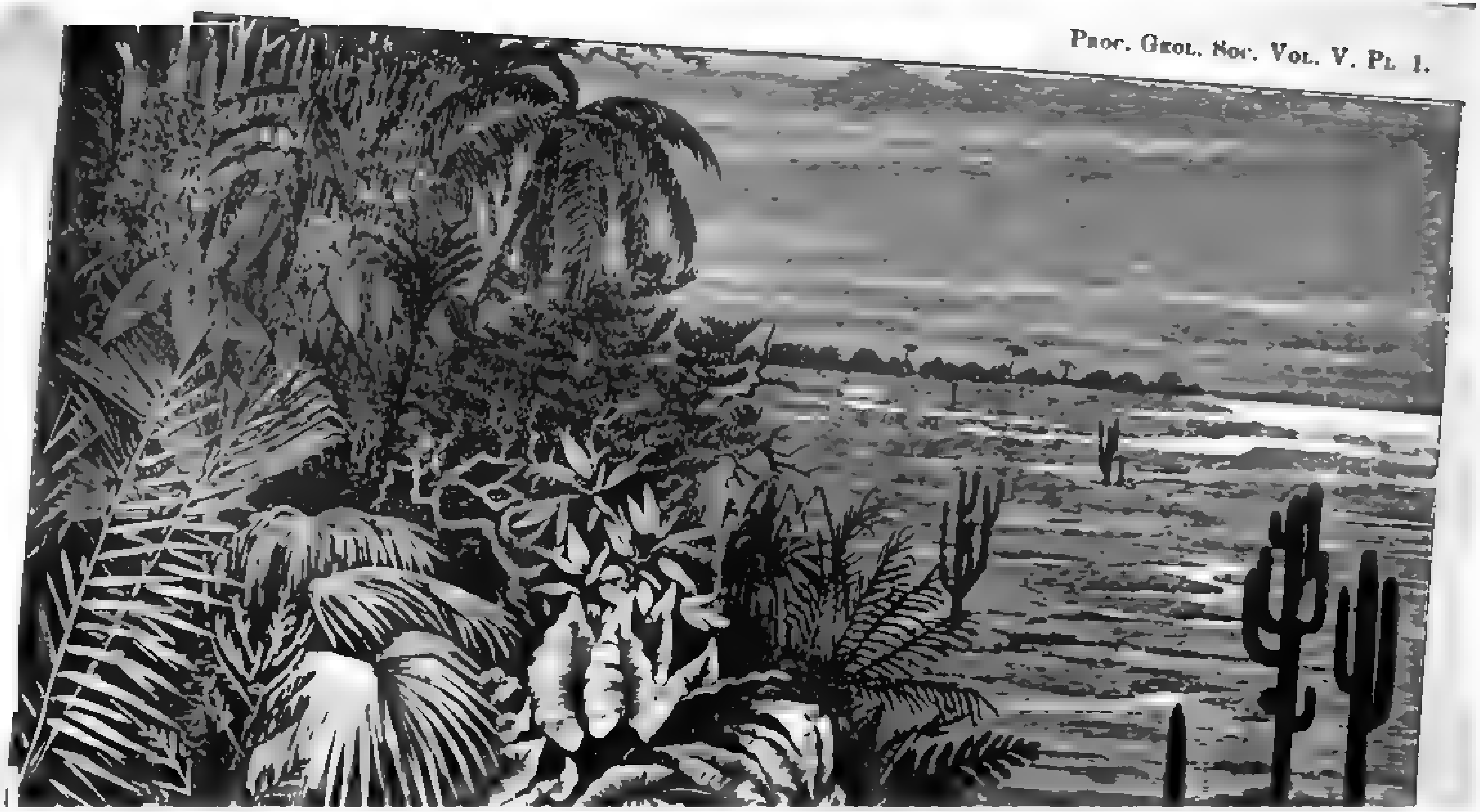
round off a panorama of volcanic peaks—all of the Burdiehouse-limestone age. A section from South Queensferry to the Bathgate Hills would only be a repetition of that first described. The denuding forces downward from the hills to the Forth shores have acted at weak lines of strata outcrop. The aqueous agencies have followed close on the lines made by the igneous ones. The igneous islets of Doo Crag and Inch-Mickery are probably the remnants of a barrier which dammed in an ancient lake

Most of the hills just enumerated are, curiously enough, on a similar contour line. It is dangerous to found much on this; but may we not infer (1) that some erupted ere the Lower series began to form, or just as they were being formed; (2) the greatest number had to do with the period just at or after the formation of the local Upper Coal Measures? (3) At the same time, bearing in mind the celerity of volcanic production, and that hard sandstones at Granton, near Edinburgh, yield remains of organisms living in the Forth—and that, at least, doubts have been raised of similar beds, formerly reckoned of undoubted Lower Carboniferous age, [see papers by the late J. Haswell, and John Henderson, in the Edin. Geol. Soc. Trans., Vol. i.]—we may admit the *possibility* that some of the peaks have erupted even in historic times.

How does the Dalkeith coal-field occupy a depression, while those in Lanarkshire and Fife form part of the regular contour rise? This must be answered ere we tackle the problem of Arthur's Seat. It, indeed, forms an integral part of it. Three years ago a portion of the water of Cobbinshaw Loch was withdrawn for canal service, from under the ice, during an intense thaw. Rows of parallel cracks appeared on the surface; then others at right angles to the first; whilst streams of water poured out on the ice at the junctions of the two sets. Here, I think, was evidence that volcanoes result from bendings and puckerings of the strata, but are not their cause; and of Professor Haughton's theory, that one force—not two, as previously assumed—may grave a district with faults or corrugations—and that if the volcanoes of central Scotland derived their material from the previously deposited strata—bendings sufficient to cause the highly inclined coal-seams would result. The problem with which this paragraph starts is, then, a mathematical one, which I leave to abler hands. But much light as to the scenic changes of the district will result from its solution. Meanwhile, let me verify the possibility of the

action I postulate; indeed, the lumps of aqueous rocks in the agglomerate of Arthur's Seat prove the existence of this mode of work. If the Lower Palæozoic beds of the Pentlands, and of Southern Scotland generally, are synchronous with their more metamorphosed representatives in the north, then, counting from the Laurentian of Lewis, a depth of nine geographical miles of aqueous strata had been formed at the dawn of the Lower Carboniferous period. But Phillips makes the source of the Vesuvian lavas to be from three to eight geographical miles beneath the crater summit. Now, may not the Silurians of the Pentlands or of Peeblesshire be part of beds wrecked by ancient volcanoes, and may we not thus account for many of the physical peculiarities of these hills and their surrounding Lower Carboniferous beds, including, perhaps, the problem of this paragraph? Vesuvius has emitted, during the last eighteen hundred years, probably three times its own bulk of lava, making a mean total material of something like one hundred cubic miles. What of the work done in Scotland by the many vents round Edinburgh during the long Carboniferous era?

In any detailed study of Arthur's Seat, the connection of its special beds with the nineteen other trap dykes found over the area covered by the city must be taken into account.



ORDINARY MEETING, January 5th, 1877.

William Carruthers, Esq., F.R.S., President, in the Chair.

The following Donations were announced :—

"Abstracts of the Proceedings of the Geological Society," No. 326; from that Society.

"Journal of the Society of Arts," December, 1876; from that Society.

"Synopsis of the Acrididæ of North America," by Cyrus Thomas, Ph.D.; from Dr. F. V. Hayden.

"First, Second, and Third Annual Reports of the United States Geological Survey of the Territories for 1867, 1868, and 1869;" "Supplement to the Fifth Annual Report for 1871;" and "Bulletin, Nos. 1 and 2," first and second series; from Dr. F. V. Hayden.

"Meteorological Observations in Utah, Idako, and Montane," by Hy. Garmett; and in Colorado and Montane Territories, by G. B. Chittenden; from Dr. Hayden.

"Synopsis of the Flora of Colorado," by T. C. Porter and J. M. Coulter; from Dr. Hayden.

"Descriptive Catalogue of the Photographs of the U.S. Geological Survey," 2nd edition, by W. H. Jackson; from Dr. Hayden.

The following were elected Members of the Association :—

Arthur Bourne Briant, Esq.; Mrs. Murray; James W. Nevins, Esq.; R. T. Graham Nevins, Esq.; George Philip Nowers, Esq., M.A.; Ernest Westlake, Esq.

The following Paper was read :—

On the Lower Bagshot Beds of the Hampshire Basin.

By John Starkie Gardner, Esq., F.G.S.

Our President asked me, when we were at Bournemouth together during the past summer, to read a paper on the Flora of the Lower Bagshots of that district. This I, with some hesitation, undertook to do, and soon found that I was placed in this difficulty —I can give scarcely any *details* of the flora found in these beds, although it is, perhaps, one of the richest in the world, as but little is known with certainty respecting it, and any

determinations I might now hazard would only imperfectly forestall the careful work which Baron von Ettingshausen and myself intend to bestow on a monograph for the Palæontographical Society. Nor can I give a complete account of their geological problems, as there are still some few data in connection with them that require examination. I will, however, give a general account of the beds, their sequence, and the conditions, as they appear to me, under which they were deposited.

I will first endeavour to give some idea of the aspect of this district. [A bird's-eye view taken from near Corfe Castle looking in an easterly direction, and a series of diagrams showing portions of cliff sections, representing in detail the appearances presented by the cliffs, were exhibited in illustration of this portion of the paper.] It is from the cliffs principally, and from the deep cuttings of the recently-constructed railway from Bournemouth to Parkstone, that our knowledge is derived. There are, in addition, the diggings carried on for commercial purposes.

Let us commence by visiting the diggings near Wareham. If we examine the cliffs and banks we there see, we find them composed of clays dark or white, or red and white mottled, of layers of coarse grey grit, and of sands of every shade of red, yellow, and white, and some are variegated. Often the sands have angular lumps of clay imbedded in them. The quarrying is mostly done in open pits, the clay being dug out perpendicularly with a long and narrow spade. Some of the deeper seams are mined, and a considerable depth is reached in Mr. Pike's workings; and at Branksea similar pipe-clay is worked under the sea level.

Overlying the pipe-clays we find another series of deposits, which are not here quarried for use, but are looked upon as refuse, but near Bournemouth are dug into in many places for the brick-earth contained in them. They are easily distinguished by the darker colour and more sandy nature of the clays. These drab clay basins are of smaller extent, and are full of remains of decayed leaves, and contain actual seams of coal, which is burnt by the villagers.

In the sheltered bay of Studland we can see but little of the cliffs, as they are now mostly overgrown to the very beach. We are struck, however, by the coloured sands, which forcibly remind those of us who are familiar with them of the still more brilliant

hues of the sands at Alum Bay. After crossing the inlet of Poole Harbour, and walking along the beach towards Bournemouth, we find the coast for the first mile composed of hills of blown sand, beyond which the cliffs we have been viewing from a distance rapidly rise.

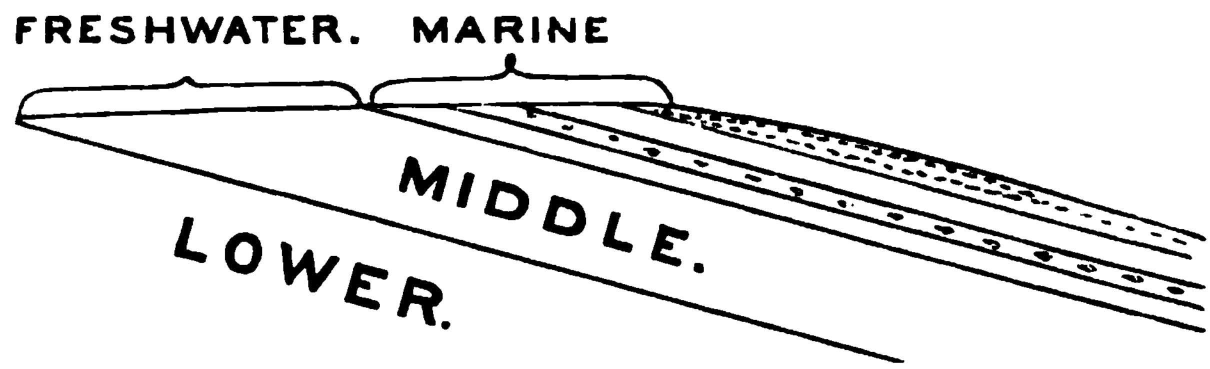
These cliffs are themselves of rather monotonous appearance, being devoid of the brilliant colouring so conspicuous at Alum and Studland Bays. Their colour varies from buff to white, and from white to slate colour. We notice apparently endless successions of clays, sands, and grits deposited at different angles and without any single bed being traceable for more than a few yards. The cliffs extend, preserving the same characters, for a distance of four miles, to near Boscombe, where we notice a change in their composition. The clays are now black and still more sandy ; the upper parts of the cliffs are far less steep, and seem composed of loose white sands and shingle, with a thick capping of gravel.

At length, still further east, in consequence of the general dip of the strata, these beds disappear beneath the sea. The sand beds which follow, when they cap the cliffs, are recognised from a great distance by their greater slope from the cliff shorewards, for they are so loosely composed that every wind blows the sand away in clouds, and leaves the shingle to rattle down on to the beach. So loose is this material that that part of the coast line which had cliffs composed of this sand has now but cliffs of insignificant height; all the sand has been blown by wind and wasted by rain, until the shingle only has been left. This is the cause of the land connecting Hengistbury Head being much lower than any other in the neighbourhood. The shingly beds are ancient sea beaches, and the slope of them to the ancient sea can still be seen in places. So long have they been exposed that the flint pebbles in them are sometimes almost decomposed, the familiar white coating of the flints being an inch or more thick.

At the peninsula of Hengistbury Head, about six miles beyond Bournemouth, the cliffs again rise, being at first composed of black, chocolate-coloured, and white sands, with pebbles; and, further on, of green clayey sands containing nodules of large irregularly-shaped concretions of sandy, argillaceous ironstone disposed in layers. Beyond Christchurch Harbour we have cliffs of white sand, which, according to my views, close the series. No order of arrangement is at first apparent in these beds, but

by going backwards and forwards over the ground attentively there is, it seems to me, a very well-marked and recognisable sequence.

Fig. 1.



I would refer to this diagram where I have expressed my reading of this district. This lower fresh-water series is seen in the neighbourhood of Corfe, and forms part of the cliffs at Studland. It is characterised by abundance of pipe-clays, and forms a thickness of possibly 200 feet.

The Middle Fresh-water series, also met with near Corfe and at Studland, forms the whole thickness of the cliffs between Poole Harbour and Bournemouth. We thus have a magnificent section four miles long and 100 feet in height. Branksea Island is also formed of this series. The entire thickness cannot yet be accurately estimated, but may be put down at some 300 feet. This series is characterised by the clays contained in them being usually brick-earth.

The next series above is Marine, and some 400 or 500 feet thick. The base beds are dark sands and clays, succeeded by pebble beds and sands, then more sandy clays with pebbles, and ending with a thick deposit of white sands. This Marine group of strata occupies the cliffs between Boscombe and High Cliff.

That this is a correct interpretation of the order of deposition of these beds is shown by the Alum Bay section, where the whole of these beds are upheaved vertically. We see in succession the lower pipe clays, the brilliant sands, the darker clays, sands, and pebble-beds one after the other, so that we can examine them in detail within the space of a few hundred yards. The thick pipe-clays and quartzose grits which we find at the bottom of the series can without the slightest hesitation be referred to the result of the wearing away of granitic rocks.

At Studland the grits are not so coarse, and at Alum Bay, a long way east, the sands are very fine; so that any one knowing the district can tell which of two specimens came from either

place. Each clay patch represents a small lake, first scooped by the running water out of the beds just previously deposited, and then filled in by sediment. The size of these old lakes is very well seen now wherever a clay basin has been quarried away, and seems to have been from about one quarter to three-quarters of a mile in circuit, whilst their depths have varied from 30 to 60 feet. These clays extend under the surface eastward, for they are worked at Branksea under the sea level, as well as at Parkstone, and near Bourne. At Alum Bay they are tilted up, and are full of fossil leaves.

The next series of beds above mark a great change in the conditions of the land. The clay patches are of smaller extent, being the filling in of mere ponds or puddles. The change indicated by these beds is one from the valley in which the last described beds were deposited to a broad low-lying tract in proximity to the sea. That this tract became gradually lowered and lowered down to the sea level is shown by the fact that in the cliffs near Poole, which are slightly lower in position than those farther east, we get only leaves of evergreens and forest trees, whilst as we work our way east, so as to meet with beds on a higher level, or, which is the same thing, of more recent age, we get a mixture of ferns and other plants, which require much moisture; whilst farther east still we get assemblages of plants that could only have lived in absolute swamps.

Low as the land appears to have become, we have no evidence whatever, throughout the whole thickness of this part of the series—amounting to 300 feet at least—that it was low enough to be inundated by the sea, as the few shells that have been found are of fresh-water kinds, with this exception—the occurrence of logs of wood bored by the *Teredo*. This isolated fact for some time presented a grave difficulty, but happening to read in Mr. Gwyn Jeffries' interesting account of the habits of this creature, I not only found that he relates the occurrence of similarly bored wood 300 miles up the river Gambia, but the distinct statement that there is a speeies which lives in fresh water. Therefore this supposed indication of marine condition may be disregarded, and we may safely infer that these Middle beds are fresh-water.

We now come to the third series of beds. A still continued sinking of the area brought this swamp so low that the sea

was no longer kept out, and, bursting through, formed great salt-water lagoons teeming with life, for we suddenly find crowds of marine forms imbedded in what was formerly blackmud.

In this series of marine beds we have at the bottom lagoon beds, as I call them, indicating the former existence of mud-banks left dry or shallow between each tide. We still find here leaves of trees, many of them doubtless overhanging the lagoons, which have so slowly decayed that they are overgrown with Polyzoa. Crowds of oysters are met with. We find the remains of shore-crabs, which overran the muddy shore, and the *Callianassa*, which bored through the mud; *Calyptræa*, *Arca*, *Corbula*, and many other shell-bearing molluscs. The Crustacea I have placed in the hands of Mr. Woodward for examination. The Mollusca are in the condition of casts, but are quite recognisable. They are forms, however, which are mostly common to both the Bracklesham and the Barton beds.

This lagoon condition continued until the gradual sinking had permitted the ever-encroaching surf to break over the lagoon barrier, and to overwhelm them with rolled shingle and sea-sand. Evidence of the lagoon condition can be traced for a mile or so east, where it has left cigar-ash coloured sands, impregnated with salt and coloured by a dark tint of carbonaceous matter. These sands contain very imperfect remains of branches of a coniferous tree resembling the genus *Dacridium* and large pieces of *Cactus*. It should be mentioned that this is the earliest cactus known, and that the spines are found to be still flexible. The sands are in other places crowded with fossil fruits, notably the Pandanus fruit, *Nipadites*, something like those met with at Sheppey. Unfortunately the salt contained in them effloresces and splits all these specimens into fragments.

We have in the series of beds, the aspect and formation of which I have endeavoured to describe, a total thickness of perhaps somewhere about 1,000 feet. We read in Lyell's "Principles of Geology," and other works, that river and delta deposits are accumulated with comparatively great rapidity, as in the case of the Rhone delta above Geneva, which has advanced 1½ miles in historical times. Throughout the Bournemouth district we have, in the great and sudden deposits of coarse grit, evidence of quick deposition. We also find leaves folded over with half an inch of sediment between the folds, and leaves sun-cracked and divided with

that or more difference in level between the segments, which also shows extreme rapidity of deposition; and although we have proof that we in some cases see the actual soil in which *some* of the smaller plants grew still penetrated by their roots, there is no evidence of its having been long occupied, or that it indicates more than a rapid fern growth between recurring floods. We have further the fine state of preservation of some of the leaves, which have been doubtless buried before decay set in, and in the breaking up and redeposition of beds, evidences of rapid accumulation; yet we must not hastily conclude that the time required for the formation of these vast deposits, was, even geologically speaking, short; for, on the other hand, beds are seen one above another which have been cut through and carried away after they had become consolidated—that is, after the muds had become so hard that they have resisted the dissolving power of water, and been rolled and redeposited as pebbles and boulders.

The same spots may have been again and again silted up and denuded before the beds finally remaining were covered up; the same material has been rearranged by different currents perhaps a great number of times, whilst the constant unconformability of the strata may indicate periods of rest or great lapses of time. All our facts as to the depression of areas tend to show that it is an extremely slow and imperceptible process, slower still when the general depression is intermittent. We have further a totally different kind of evidence, which to my mind is still stronger, of the vast ages that rolled away during the deposition of these beds. This is the significant fact that the entire marine fauna was completely changed. By this I mean that we have in the London Clay a fauna which migrated away—a fauna familiar to us, and characterised by great nautili and other shells, and Crustacea peculiar to it. In the succeeding Bracklesham Beds we have another totally distinct fauna, so that the time of the land period was sufficiently great for the fauna of the London Clay sea to be entirely changed before the return of the sea whose fauna we have recorded in the Bracklesham Beds. In the Barton Beds which overlie the Bournemouth deposits we have again an extensive fauna most distinctly characterised and widely separated from that of either of the preceding beds just mentioned. In many cases it is recognised that variations in fauna are

dependent upon the depth of the sea; but such cannot be the case in this instance, since we get species belonging to the same genera so closely resembling each other that we cannot but infer that they lived under similar conditions. And when we come to see, as we do, that this applies to all the groups, the inference drawn from one individual group accumulates to an evidence which presents itself as at any rate approaching certainty.

The well-known case of the differences in the fauna of the Red Sea and the Mediterranean, which are separated by so narrow a strip of land, has been often referred to as a possible explanation of how different fossil faunas occurring close together may have existed contemporaneously, and do not imply any lapse of time during which changes of climate occurred; but although in many cases it is impossible when a purely hypothetical theory is brought forward to bring an argument to disprove it, yet in this case there is no evidence whatever in its favour, and what little evidence there is bearing on the question is directly opposed to it; therefore the other seems the more reasonable explanation.

The great changes in the flora, which I shall mention to you, although principally due perhaps to the great change of level of which we have other indications—may also indicate long lapse of time—long enough, as I have said, for the marine fauna of Bracklesham to develope—to disappear and give place to that of Barton.

I do not know whether we shall ever be able to estimate geological time, but astronomers tell us that a cold period recurs about every 26,000 years, and it seems to me to be probable that we may get some data in this direction on which we may build our hypotheses. In the English Eocene we appear to have the deposits of a cool period as shown by the Mollusca of the Thanet Sands. The Plastic Clay may represent a cold period, the London Clay indicates, as we all know, a hot period, becoming cooler in the Lower Bagshots and again reaching a tropical character in the Bracklesham Beds epoch. The overlying Barton Beds indicate a slightly cooler condition, again becoming tropical in the Headon Beds of Hordwell; the Bembridge and Hempstead Beds show a decreasing temperature, quite temperate at the top of the latter. In the Miocene, Heer has ascertained that there was an increasing temperature. Each cool period was not necessarily a glacial one, and even had glacial conditions ever prevailed in Eocene times, it

is hardly possible to conceive that land vestiges of glaciers could have escaped complete obliteration.

I will now call your attention to the leaves.

These leaves are found in various conditions of preservation. In most cases the impression only of the leaves in the clay is met with, but in some cases they are so well preserved that the actual substance has been retained, although chemical changes have altered its composition, and will peel off and blow away. In some of the clays the masses of leaves are so decayed and rotted that they cannot be recognised, and are not worth our collecting. Where the preservation is good we can readily distinguish the various original textures of the leaves by comparing their general aspect and colour both among themselves and with existing forms. For instance, those which are thick, as evergreens; thin, as convolvulus; hard, as oak; or soft, as lilac; or even velvety, as the common phlox, can all be recognised. Their colours, in most of the beds, vary from buff to brown. Whilst these various shades of dark buffs and browns are in many cases the result of chemical change that has taken place after the leaf was covered up, yet I believe that in many cases this change had occurred, at least partially, before the covering up, just as we saw a few weeks ago the changed colours of the fallen leaves of autumn. In the darker clays the remains are black and completely carbonised; where this is so the finer venation is indistinct and the remains difficult to save, so that we may discard them unless the outline of the leaf is of unusual form. The darker browns, I take it, indicate hard and evergreen leaves; for instance, the laurel like leaves are always of a deep colour, whilst both the thin and the succulent leaves are always of light colour, as in the leaves which we suppose to be fig, some species of *Smilax*, &c. No other colours have been met with, with one remarkable exception; fragments of a reed-like aspect are found of a deep violet, staining the surrounding clay mauve for a considerable distance.

These deposits, which have been neglected by geologists, are of extreme importance, as being one of the few records we have of land surface. The rocks in which organic remains are found are aqueous rocks, principally marine; the remains of aquatic animals are more numerous than of those living on land, and are for the same reason far more numerous than remains of plants. Such facts as these give great interest to series of land remains of so

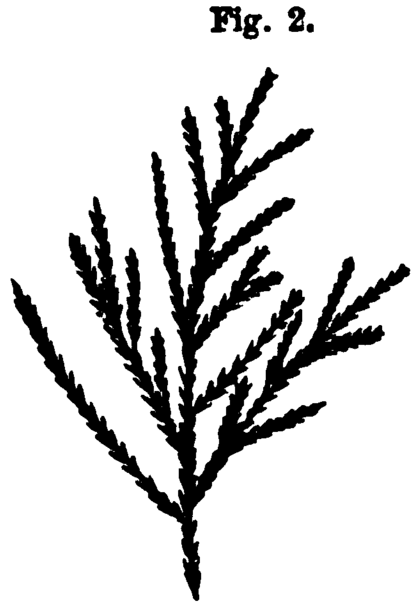
complete a nature. We can form an idea of how incomplete our terrestrial records are when we consider that whilst upwards of 4,400 plants are found growing in Great Britain, about 700 only are known fossil, whilst 513 testaceous Mollusca now inhabit Great Britain, and 4,590 were known fossil as far back as 1862. The beds are believed to be of the same age as the great series of beds at Bagshot Heath, described by Prestwich, in 1847.

The Bournemouth flora appears to consist principally of trees or hard-wooded shrubs, comparatively few remains of the herbaceous vegetation being preserved.

Parasitic fungi are abundant. Ferns, extremely rare in the lower part of the series, become abundant, as far as the remains go, almost to the exclusion of other vegetation towards the close of the middle period. The prevailing group seems that of *Acrostichum*, of which several species are present. We can also determine with almost certainty the presence of *Angiopteris*, *Anemia*, *Nephrodium*, *Gleichenia*, *Lygodium*; there are, besides these, several undetermined forms.

Of conifers we have *Cupressus* and *Taxodium* determined by De la Harpe, with the addition of *Dacridium*, and indications of *Pinus*. Cycads have disappeared.

Fig. 2.



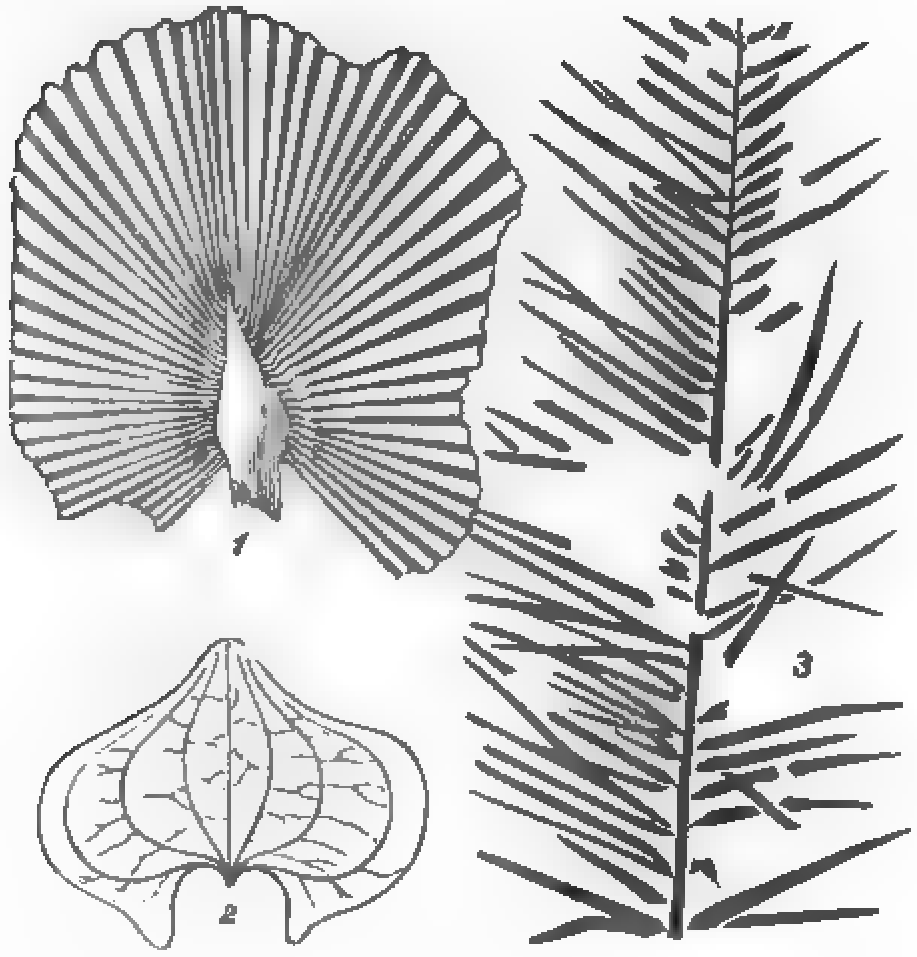
BRANCH OF CONIFER

Of Monocotyledons we have plentiful remains of reeds and rushes. Screw-pines are represented by *Nipadites*. Palms are very abundant, especially in the lowermost beds of Corfe and Studland, and the upper middle beds of Bournemouth. Massolongho has determined *Chamæcyparites*, in addition to which many fan and feather palms exist belonging to *Flabellaria*, *Sabal* and *Phœnicites* and a genus new to the Eocene, *Iriartea*. A gigantic Aroid is also very abundant, and the *Smilaceæ* occur in all the fossiliferous beds throughout, and are represented by at least five or six species.

The Dicotyledons are most abundant, and it is probable that a vast number of species will be determined from these beds. De la Harpe's list included, in 1856:—

Apetalæ.—*Populus, Ulmus, Laurus, Quercus, Artocarpidium*; and *Daphnogene* is since added, fide Massolongho; to which we may now add *Carpinus, Fagus, Castanea, Salix, Platanus, Ficus* (abundant), *Celtis*, numerous Proteaceæ, *Cinnamomum*.

Fig. 3.



GROUP OF MONOCOTYLEDONS

Polypetalæ.—*Elæodendron, Rhamnus, Prunus, Juglans, Cluytia*, have been already noticed by De la Harpe. We add, fide Massolongho, *Ceratopetalum*, and, as new to the Bournemouth flora, *Acer* (Many sp.), *Dodonæa, Celastrus, Eucalyptus*, and a number of *Leguminosæ*.

Monopetalæ.—De la Harpe has determined *Diospyros*. To this may perhaps be added *Porana*.

To Eocene Dicotyledons we may here add for the first time, amongst many others, *Cactus* and *Stenocarpus*.

In addition to these we have probably represented almost every genus described from Continental Eocene floras, but it is premature, for the reasons already stated, to go farther into this question at present. The forms I have mentioned will give a general idea of the composition of the flora.

It has been very generally noticed by students of the fossil Tertiary floras, that the Eocene vegetation presents us with types

Fig. 4.

LEAVES OF DICOTYLEDONS.

peculiar to the Southern Hemisphere, and related to those of Australia and the adjacent islands. We may cite, for example, the *Eucalyptus*, Proteaceæ, many Leguminosæ, and Coniferæ, whilst of the figs, although we cannot speak of them so positively, we see that they bear a striking similarity to forms now existing in Australia.

Unger* has speculated upon the manner in which the vegetation of a continent situated at our very antipodes could have found its way hither, and supposes that the route they have taken must have been by way of Asia, as the ranks of this Australian flora seem to have been largely recruited on the way by Asiatic forms. The Challenger chart, however, affords another hypothesis.

* "New Holland in Europe," Journal of the Botanical Society, January, 1865, p. 12.

Mr. W. S. Mitchell, who some time ago devoted much time to the study of these floras, called attention to this in "Nature," a fortnight ago, in the following note:—"There is a narrow belt of sub-oceanic highlands extending in a sinuous course down the length of the Atlantic, as shown in the Challenger chart, which removes a difficulty that has been present to students of fossil botany. When the area was land, these hills would probably form a ridge sufficiently high to have a temperature cool enough to explain the migration across the tropics of plants living in a temperate or even cooler climate." We may, therefore, now infer from the presence of *Banksia* and innumerable other instances of Australian forms, both faunal and floral, that a once continuous area has been broken up, and that many physical changes have taken place. As an additional proof of this I may mention, that it is stated by Unger that many European plants existed in Australia before it was discovered by us.

A fact still to be ascertained is whether the flora now confined to Australia predominated in all suitable regions of our hemisphere during Eocene times, and especially whether it *then* grew in Australia—whether it spread from Australia here, as Unger supposes, and has perished everywhere but in its habitat; or whether its original *centre* was in Europe in Eocene times and has since *migrated* to Australia. The *Miocene* flora is distinctly stated by all who have investigated the subject, to have remarkable generic and ordinal analogies with that which prevails in North America at the present time. A certain proportion of Western forms, such as oak, maple, poplar, is seen in the list I have read of our Bournemouth flora to be mingled with the Australian-like vegetation just mentioned, foreshadowing the greater arrival of Western forms which occupied Europe at a later time. The almost complete change of flora in the Miocene, from the flora prevailing in the Eocene, is not such a change as we should find brought about by lapse of time alone. It may more probably be accounted for by the intervening occurrence of a cold period such as we see shadowed in the Hempstead Beds at the close of the Eocene, during which the colder temperature closing in from the north drove the existing vegetation south. On the recurrence of suitable conditions, the western flora occupied the grounds, which we may suppose the southern forms were unable to re-occupy from some cause, such as the impossibility of their recrossing the

Equator owing to the depression of the high-land ridge, or other causes which are so obvious that it is needless to bring them forward here. It is probable, on botanical evidence, that this American fauna, came by way of the Aleutian Islands* and Asia, and not direct by way of an Atlantic continent or island, as supposed by Unger.

Jukes' remarks that "there is perhaps a closer relation between those recently extinct European genera of animals and plants and the existing North American ones, than there is between the latter and the present European genera." "The present European flora may be of more recent date than that of North America; genera and species once common to both have remained less changed in North America than in Europe, where they have become extinct and been replaced by other forms. The climate has possibly altered less there in Glacial times than here." As the present North American flora has not materially changed since Cretaceous times, there can be no doubt that it is the progenitor of a large portion of the European Miocene flora. If the Australian flora should be found to be more ancient than our Eocene period, it would follow that the greater part of the European Tertiary floras known to us were not indigenous, but introduced from other lands.

It is solely, with the exception of glacial and possibly pluvial evidences, from the nature of the animals and plants that have left their remains in the rocks, that we can draw any certain conclusions as to the kind of climate possessed by different parts of the earth where animals and plants lived. When we find in the British Islands the remains of crocodiles, turtles, large nautili, together with palms and other plants of tropical aspect, we cannot resist the conclusion that the climate of the British Islands must have been more like that found in the Tropics than that which they at present possess. From the abundance of palms and figs, and other tropical plants, we might infer extreme heat, whilst the *predominance* of evergreens implies at least an absence of severe winter cold. The presence of more temperate forms has, however, to be taken into consideration.

The question arises as to how it is possible that the tropical forms, such as the ferns, palms, aroids, *Cactus*, *Pandanus*, &c., could have grown alongside of the apparently temperate forms, as, for example, the oak and beech, and the Australian Myricaceæ,

* Olliver, "Natural History Review," April, 1862.

Proteaceæ, Cupressinæ, &c., which also denote a climate but little warmer than ours. There have been for the area which is now England many alternations of long periods of heat and cold. Whenever the area became warmer, the descendants of semi-tropical forms would gradually creep further and further north, whilst the descendants of cold-loving plants would retreat from the advancing temperature *vice versâ*, whenever the area became gradually colder, the heat-loving plants would, from one generation to another, retreat further and further south, whilst the cold-loving plants would return to the area from which their ancestors had been driven out. In some cases the palms may be but remnants of the retreating vegetation preserved in sheltered spots near the sea-shore, and protected by the influence of warm currents.

It must, too, be borne in mind, that it is not so much the mean temperature of a whole year which affects the possibility of plants growing in any locality, as the extremes of summer and winter temperature. For example, one place may have a mean winter temperature of 50°, and a summer one of 70°; while another place might have a mean winter temperature of 20°, and a summer one of 100°, and yet both have a mean *annual* temperature of 60°. At Glengariff, in the West of Ireland, in the midst of a northern vegetation, we find sub-tropical forms as *Trichomanes radicans*, *Hymenophylla*, mosses, Hepaticæ and lichens now only elsewhere met with living in the Antilles and Mexico.

I have repeatedly been surprised in North Germany to find large palm-houses kept at temperatures which struck me as quite chilly, no heat being applied in summer, and but just sufficient in winter to keep the frosts out. At Hanover there is an example of this, in which case the palms have so far outgrown the size of the house that they have to be sunk in wells several feet deep, and have so spread that they seem in danger of suffocating each other. In a fernery of our own, simply glazed, the European palm and sub-tropical ferns grow without any artificial heat whatever, and withstand a considerable amount of frost. It is not so much the cold during the period of winter quiescence which destroys plants as the unexpected chills of spring, after the sap has commenced to rise. Southerly forms may, therefore, grow many degrees further north, where, with even a severe winter, the spring is unbroken.

Darwin reports that the island of Chiloe 42° S. lat., which enjoys but little summer heat, and is enveloped in continual rains

and mists, possesses an extraordinarily rich flora, recalling that of Brazil. The tropical forms push farther south, in spite of apparently less favourable climatal conditions, in consequence, probably, of the more equable temperature produced by the greater preponderance of sea. Perhaps Europe in Eocene times, divided and in great part submerged, approached nearer in climate to Chiloe. Looking, however, at the extremely tropical nature of the fauna of the Bracklesham and the London Clay beds, there can be no doubt that a high temperature did prevail—at all events, during a part of this period. The fact of the existence of remains of plants being found opposite Disco, in latitudes which at present have three or four months' darkness and a cold temperature, is still most difficult to explain.

When we draw inferences as to climate from plant remains we must consider how far differences of level account for different floras. According to the height of the land on which the trees grew, of which leaves were floated down, might depend the more or less tropical or temperate aspect of the flora. On the southern slopes of the Tyrol I have frequently passed from an Alpine region to plantations of sugar-canes, oranges, &c., in a few hours. Ascending from the sea at the Equator to the summit of the snow-capped mountain, we should find as much change for every hundred feet vertically as we should in travelling towards the Pole in hundreds of miles laterally. According to Meyer, we should reach the level of figs at 2,000 feet, myrtles and laurels at 4,000 feet, and evergreens at 6,000; European dicotyledons at 8,000. Supposing the leaves to have been brought down from these different levels, we should have an explanation of the mingling of forms and the localised character of the flora of each clay-patch. But I fear this explanation must be rejected, as we have no evidence in the condition of the leaves of any such distant transport as this would imply, but the evidence tends to show that the leaves must have grown close to the spot in which they are buried.

Some of the patches contain leaves which appear to have had a very barren and sandy soil to grow upon, and are characterised by small hard lanceolate leaves, as if of scrub bushes. Where in these patches a leaf is met with which is common to other beds, it is dwarfed. Other beds seem to show an extremely luxuriant soil and very sheltered condition.

It will have been gathered from the anniversary Addresses of

our President that the remains of plants are, if possible, of more interest and importance than those of marine animals, as whilst we have already *some* idea of the succession and development of animal life, especially of the more purely marine Orders of Crustacea, Mollusca, Echinodermata, &c., we know very little of the history of the development of plant life. Our President laid stress on the somewhat sudden occurrence of dicotyledons as being unfavourable to the hypothesis of evolution in descent. I concur with him fully that it is difficult to realise that the absence of dicotyledons can be due to any cause but their absence from the then existing vegetation; yet there are certain causes tending to make their preservation difficult, which, perhaps, may be taken into account.

Some kinds of coniferous plants resist decay when immersed in water more completely than do almost any dicotyledons, and this resistance may, owing to their resinous nature, be very greatly increased when the immersion is in sea water. This supposition is borne out by a fact I have noticed, that in some Eocene beds, such as the marine beds at Bournemouth, the Bracklesham Beds, and the Bembridge Marls, coniferous remains preponderate, whilst from the two latter places I have never seen remains of dicotyledons at all, although there is evidence in these cases that dicotyledons were abundant on surrounding land areas. This may partly account for their complete absence in marine Cretaceous rocks in England, where, as in the Gault, &c., foliage, fruit, and resinous gums in the form of amber, the remains of Coniferæ, are preserved. The foreign Cretaceous rocks in which dicotyledons are met with, are principally, I think, of fresh-water origin. It should be borne in mind that our Chalk period contains a deep sea fauna, and we have no record in England as to what were the prevailing contemporaneous forms of life on land in other regions.

I have great doubts as to the correct position of many of the foreign so-called Cretaceous beds. Those of America, from which most of the list of dicotyledons of this period are derived, appear to me, from the character of their fauna, to, perhaps, fill in the gap between our Chalk and the Lower Eocene. Most of the shells have a marvellously Eocene-like aspect, and I take it that the presence of ammonites and some few other forms of shells, which in England do not range above the Chalk, should not be taken as conclusive evidence of the antiquity of

a bed, as, although extinct in our seas, they may very well have survived in other regions. It is inconsistent to assume that no ammonite lived in any part of the world to a more recent period than that of our Chalk. The finding of *Pleurotomaria* and other supposed extinct Cretaceous shells in Australian waters should not be forgotten. The same doubts apply to many of the European leaf-deposits. Many of these are isolated patches, and their age has been inferred rather from the character of the leaves than from their stratigraphical position. The age of many of the so-called Miocene leaf-beds is admitted now to be extremely doubtful. What little evidence we may expect to find in these beds seems to me likely to be in *favour* of the theory of evolution, although, until the flora has been worked out, it is premature to offer an opinion. By far the greater number of the plants belong to the lowest division of the dicotyledons, the Apetalæ, a minority are polypetalous, whilst not one, as far as I know, can with certainty be assigned to the highest (according to Haeckell) group—the Monopetalæ.

Professor Ettingshausen has traced the gradual development of some of the Miocene forms into existing species—notably that of *Castanea atava* to *Castanea vesca.* When he was here last summer, and saw my collections, he especially picked out the *Castanea* from Bournemouth as carrying the history of this genus a step farther back, linking it with the oak, as it possesses an oak-like character of venation.

I would merely add that many botanists, as Unger, Schimper, and others who have studied fossil plants, are profoundly impressed with the amount of evidence that has already been brought forward in support of the theory of evolution.

ANNUAL GENERAL MEETING.

February 2nd, 1877.

William Carruthers, Esq., F.R.S., President, in the Chair.

The Honorary Secretary read the following

REPORT OF THE GENERAL COMMITTEE FOR THE YEAR 1876.

The General Committee, in presenting their Report, have great pleasure in congratulating the Members upon the continued progress of the Association.

The number of new Members elected exceeds even that of last year, and as the losses by death or otherwise have been much smaller than for some years past, the consequent increase is very considerable, as the following Table will show:—

Members elected during 1876 . . .		52
Deaths	3	
Withdrawals and exclusions	11	
		14
Increase		38

The Census of the Association on the 1st of January, 1877, gave the following results:—

Honorary Members	15
Life Members	50
Old Country Members	23
	88
Other Members	302
	390

The Finances of the Association are in a satisfactory condition. Upon reference to the Balance Sheet it will be perceived that the sum of £48, recommended by the late Committee to be invested (see Report for 1875), has been applied in the purchase of Consols. The Association now possesses £258 5s. 5d. Consols, producing a yearly income of nearly £8, which, together with the revenue derived from the sale of publications, yields a material addition to its resources. The Committee suggest that the whole of the Life

Compositions for the past year, amounting to £21, be likewise invested, as this can be done without at all interfering with the expenditure necessary for the efficient maintenance of the work undertaken by the Association.

Although there is such a material increase in the number of Members, the receipts from fees and annual subscriptions are only £3 in excess of the amount taken last year: this arises partly from the subscriptions not being always paid in the year of election, but principally from the fact that the revenue of 1875 was materially increased through the payment of arrears. It is very satisfactory to find that exclusions for non-payment during the past year have been very few indeed; there are, however, about twenty-five subscriptions for the year 1876 still unpaid.

The cost of the Proceedings is almost exactly the same as in the year 1875. There is a large item under the head of Miscellaneous Printing: this is partly owing to the production of a more copious catalogue of the library, with a new classification. A further outlay in this direction may be necessary during the ensuing year, as your Committee intend printing a supply for future use. In consequence of this arrangement it will not be deemed necessary to issue catalogues along with the Annual Report and List of Members. This will entail a considerable expenditure at first, but with the certainty of saving money ultimately. The item for the purchase of books is also a large one, and altogether the Library may be deemed to have been one of the principal spending departments of the Association during the past year. At the same time it is satisfactory to know that these purchases have been made with judgment, and on reasonable terms, and that the advantages of increased library accommodation are fully appreciated.

The increase under the head of Miscellaneous Items is due to the appointment of an Assistant at the evening meetings. Mr. Johnston-Lavis has discharged this duty very efficiently, and your Committee consider that his appointment has been of great service to the Association. The increase in the number of Members of course necessitates an increase in the postage of circulars, Proceedings, &c.

It must be remembered that the large balances left with the Treasurer in former years were partly owing to an accumulation in the hands of the last Treasurer but one, the whole of which was only rendered available during the early part of the past year.

For instance, on the 1st of January, 1874, there was a balance of £136 6s. 3d., whilst the present account shows a balance of £71 1s. 6d. On the other hand, since the former period, a sum of £123 15s. has been invested in securities bearing interest. The present balance, even after a further investment of £21, will be ample for immediate requirements.

The Lectures and Papers, which have been read or delivered before the Association, have attracted considerable attention amongst the Members, as the very good attendance at the evening meetings and the interesting discussions testify. It is hoped that the two Addresses delivered by the President will appear together, and form the commencement of Vol. v. of the Proceedings: the value of these addresses, when published, will doubtless be fully appreciated. An admirable Lecture by Dr. Hector, on the Geology of New Zealand, was listened to with the greatest interest.

The following is a list of the Papers, &c., brought before the Association during the year 1876:—

On the Geology of New Zealand, with special reference to the Drift of that Country, by Dr. HECTOR, C.M.G., F.R.S.

On the Drift of the North Wales Border, by D. C. DAVIES, Esq., F.G.S.

On the First Irish Cave Exploration, by G. S. BOULGER, Esq., F.G.S.

On the Bagshot Sands in the Isle of Sheppey, by Major F. DUNCAN, R.A., LL.D., F.G.S.

An Appendix to Major Duncan's Paper, with an account of some remarkable rock fragments lately discovered in the Mill Hill Cutting, by W. H. SHRUBSOLE, Esq.

Known Facts and Unknown Problems in Arctic Geology, by C. E. DE RANCE, Esq., F.G.S., of the Geological Survey.

The Volcanoes of Iceland and their Products, with special reference to those Mountains which have recently erupted, by WILLIAM LORD WATTS, Esq.

On the Section of the Chloritic Marl and Upper Greensand, on the northern side of Swanage Bay, Dorset, by H. GEORGE FORDHAM, Esq., F.G.S.

Notes on the Geology of the Neighbourhood of Swanage, by W. R. BRODIE, Esq. (*Abstract.*)

Notes on the Geology of Lewisham, by H. J. JOHNSTON-LAVIS, Esq., F.G.S.

On the Geology of Brighton, Part 2, by J. HOWELL, Esq.

On the British Palæozoic Arcadæ, by J. LOGAN LOBLEY, Esq., F.G.S. F.R.G.S., &c.

Opening Address, Session 1876-7, by the PRESIDENT.

On the Comparative Ages of the English and Scottish Coal Fields, illustrated by the Geology of the Lothians and Fifeshire, and the structure and age of Arthur's Seat, by ANDREW TAYLOR, Esq., F.C.S.

During the year 1876 the following Museums and collections were inspected :—

British Museum :—	
Felspars and Micas	Prof. Maskelyne.
Museum of the Geological Society:—	
South African collection	Prof. Rupert Jones.
Natural History Museum, Nottingham ...	Rev. A. Irving.
Alpine Gardens, Belvoir Castle	W. Ingram.
Collection from Purbecks of Swindon ...	Charles Moore.
Collection from the Wenlock Shale of Bryn Sylwrn	Mr. Ruddy.

The Excursions of the Association have been better attended than even during the previous year, and some of those to districts near the metropolis attracted a very large number of Members. These excursions become more and more the leading feature of the Association, and contribute in a great degree to its usefulness and popularity. As there have been plenty both of long and short excursions, the tastes of all classes of Members have been thereby gratified. The readiness with which local geologists and men of eminence have responded to the invitations of your Committee is most satisfactory, nor has there been any difficulty in obtaining efficient Directors from amongst the body of Members.

Subjoined is a list of the Excursions made during the year 1876, arranged in the order of the formations visited :—

PERIOD.	FORMATION.	LOCALITY.	DATE.
Post Tertiary.	Deposits in Thames Valley.	Reading.	June 3.
„	Elephant Gravels.	Aylesford, Folkestone.	May 1, June 19.
„	Drift of North Wales Border.	Chirk, &c.	July 17, &c.
Eocene.	London Clay (and Oldhaven Beds).	Bromley, Hatfield, Reading, Blackheath.	April 22, May 13, June 3, July 1.
„	Lower Tertiaries.	Sundridge & Chiselhurst.	April 22.
„	„	Hatfield.	May 13.
„	„	Reading.	June 3.
„	„	Charlton.	July 1.
Cretaceous.	Upper Chalk.	Chiselhurst, Hatfield, Reading.	April 22, May 13, June 3.
„	Chalk.	Kits Coty House.	May 1.
„	Chalk Marl.	Folkestone.	June 19.
„	Gault.	Aylesford.	May 1.
„	„	Folkestone.	June 19.
Neocomian.	Folkestone Beds	Folkestone.	June 9.
„	Sponge Gravels	Faringdon.	June 6.
Jurassic.	Purbeck and Portland Beds.	Swindon.	June 5.
„	Kimmeridge Clay.	Swindon.	June 5.
„	Corallian.	Faringdon.	June 6.
„	Great Oolite.	Essendine.	April 17.

PERIOD.	FORMATION.	LOCALITY.	DATE.
Jurassic.	Lincolnshire Limestone (Inferior Oolite).	Ponton.	April 17.
"	Middle Lias.	Denton and Belvoir.	April 17.
Rhætic & Triassic.	Rhætic and Keuper.	Elton.	April 17.
"	Bunter Sandstone.	Cinder Hill.	April 18.
Permian.	Upper Permian Marls.	Cinder Hill.	April 18.
"	Magnesian Limestone.	Mansfield, &c.	April 18.
"	Lower Permian Sandstone.	Kimberley.	April 18.
Carboniferous.	Coal Measures.	Kimberley.	April 18.
"	"	Trevor.	July 21.
"	Millstone Grit.	Offa's Dyke, Dolcoch, Trevor.	July 17, 19, 21.
"	Carboniferous Limestone.	Offa's Dyke, Dolcoch, Eglwseg Rocks	July 17, 19, 21.
Upper Silurian.	Wenlock Shale.	Llanderfel.	July 20.
"	"	Llangollen.	July 21.
"	Tarannon and Llandovery.	Glyn Ceiriog.	July 18.
Lower Silurian.	Bala or Caradoc.	Glyn Ceiriog and the Berwyns	July 18, 20.
"	Llandeilo.	Glyn Ceiriog and the Berwyns	July 18, 20.
Igneous, or Metamorphic.	Greenstone (Diorite ?) Porphyries. Felspathic Rocks.	Glyn Ceiriog.	July 18

DIRECTORS OF EXCURSIONS DURING THE YEAR 1876.

Mr. W. H. Holloway, F.G.S., of the Geological Survey; the Rev. Alexander Irving, B.A., B.Sc.; Mr. J. Logan Lobley, F.G.S.; Professor John Morris, F.G.S. (on four occasions); Mr. John Hopkinson, F.L.S., F.G.S.; Professor Rupert Jones, F.R.S.; Mr. Charles Moore, F.G.S.; Mr. E. C. Davey, F.G.S.; Mr. F. G. H. Price, F.G.S.; Mr. D. C. Davies, F.G.S., and Mr. Henry Hicks, F.G.S.

The thanks of the Association are especially due to the following noblemen and gentlemen for assistance or hospitality:—Professor Maskelyne, F.R.S.; Professor T. Rupert Jones, F.R.S.; His Grace the Duke of Rutland, K.G.; Mr. W. Ingram; Mr. E. Wilson, F.G.S.; The Most Noble the Marquis of Salisbury, K.G.; Mr. John Jones, F.G.S.; Mr. Stanley Leighton, M.P.; Mr. Ruddy; Professor M'Kenny Hughes, F.G.S.; Mr. John Dovaston; Mr. J. R. Barnes and Mrs. Barnes, of Brookside House.

Considerable additions have been made to the Library during the past year, by purchase as well as by donation. A list of the purchases has been given in the December circular, and the donations are regularly announced in the Proceedings of the Association.

The publications of the United States Geological and Geographical Survey of the Territories, presented by the Director, Dr. F. V. Hayden, are, however, so valuable and important as to call for special mention. The quarto series, of which several volumes have been presented during the year, will form a splendid monument to the industry and talent of the officers of the Survey, and to the liberality of the Government of the United States. Both in their text and plates the volumes are unequalled by the publications of the Surveys of any other country.

The attention of your Librarian has been chiefly directed to the improvement of the Library Catalogue, and it is hoped that the arrangement adopted in the list of books and pamphlets appended to the last Report will facilitate the finding of any work required, and will also be not without value in a bibliographic point of view.

A fourth volume of the Proceedings of the Association has been completed. This volume contains 23 papers printed *in extenso*, 27 reports of excursions, besides abstracts of several papers, &c. Your Committee doubt if there is any work of equal size which contains so wide a range of geological information adapted to the wants of the less as well as of the more advanced students of the science.

The large number of societies which exchange publications with us, and the increasing sale, attest the estimation in which the Proceedings are held; and in view of the adequate revenue now in possession of the Association, and with a desire to extend the influence and increase the usefulness of the Association, the Committee have decided to print a sufficiently large edition of each future number to allow of copies being sold to the public.

Mr. William Carruthers, F.R.S., Keeper of the Botanical Department of the British Museum, now retires from the office of President. It has been a fortunate circumstance that the services of so able a successor to Mr. Henry Woodward were secured to the Association, and your Committee consider that much progress has been made during Mr. Carruthers' tenure of office. He has always displayed an interest in your affairs, as his presence at several of the Excursions, the valuable Papers which he has obtained for the Association, and the two important Addresses he has delivered, will testify. By obtaining the counsel and sanction

of scientific men of such eminence, the Proceedings of the Association acquire additional importance, and the educational benefits thus derived are shared by all the Members who care to avail themselves of such opportunities.

Your Committee have much pleasure in proposing as Mr. Carruthers' successor John Morris, Esq., F.G.S., Goldsmid professor of Geology and Mineralogy in University College. Of all the scientific men who have kindly lent their aid from time to time in building up the fabric of the Association, none have been more constant in their endeavours, or more successful in their methods for the promotion of its objects, than Professor Morris, who has thus laid all the Members under a deep obligation. It is true that he has already filled the chair for a period of three years, viz., from 1868 to 1870 inclusive, at a time when the prospects of the Association were by no means bright. Your Committee, therefore, venture to think that it would be a fitting compliment on the part of the Members once more to offer the chair to so constant a friend, feeling sure that the Association may look forward to the maintenance of its utility and progress under his auspices.

The Committee regret to have to announce the retirement of your Honorary Secretary, Mr. Wilfrid H. Hudleston, M.A., F.G.S., &c., who, after three years' unremitting attention to the affairs of the Association, finds himself unable to continue to give that amount of time and labour which the discharge of the duties of the office requires. The industry and ability Mr. Hudleston has displayed in conducting the secretarial work generally, but especially in the organisation of the Excursions and in the preparation of reports which carefully record the scientific work accomplished, entitle him to the lasting gratitude of the Association.

The Committee beg to recommend as his successor John Foulerton, Esq., M.D., F.R.S.E., F.G.S., whose scientific knowledge and the interest he takes in the work of the Association, as evidenced by his assistance at the principal Excursions for years past, well fit him for the position of your Honorary Secretary.

Your Committee again offer, on your behalf, the best thanks of the Association to the Council of University College for the privilege of holding the meetings in the Library of the College, as well as for the courtesy and assistance accorded on all occasions.

Subjoined is the Balance Sheet for the year 1876 :—

BALANCE SHEET OF RECEIPTS AND DISBURSEMENTS

For the Year ending December 31st, 1876.

Dr.

	£	s.	d.	£	s.	d.
By Balance, January 1st, 1876 ...				110	4	0
,, Admission Fees	23	0	0			
,, Annual Subscriptions	141	1	0			
				164	1	0
,, Life Compositions				21	0	0
,, January Dividend on £207 9s. 6d. Consols ...				8	1	8
,, July Dividend on £258 5s. 5d. Consols ...				8	16	6
,, Sale of Publications				8	1	8
				£310	4	10

Cr.

	£	s.	d.
To Printing and illustrating "Proceedings"	93	13	9
,, Miscellaneous Printing, including the Report, List of Members, and Library Catalogue	27	16	11
,, Library	22	11	11
,, Gas, Attendance, and Miscellaneous Items...	12	17	3
,, Postages	29	15	0
,, Stationery	4	8	6
,, Purchased £50 15s. 11d. Consols	47	18	9
,, Broker's Commission	0	1	3
Balance	71	1	6
	£310	4	10

We have examined the Accounts of the Geologists' Association, and we find that, according to the books laid before us, a sum of Seventy-one Pounds One Shilling and Sixpence remained in the hands of the Treasurer on the 31st December, 1876.

January 17, and
January 22, 1877.

M. MOGGRIDGE,
WM. H. LEIGHTON, } *Auditors.*

The Report of the General Committee was unanimously adopted as the Annual Report of the Association for the year 1876.

The Ballot having been completed, the President announced that the following had been elected

GENERAL COMMITTEE AND OFFICERS

for the ensuing year :—

PRESIDENT.

John Morris, Esq., F.G.S., Professor of Geology in University College.

VICE-PRESIDENTS.

William Carruthers, Esq., F.R.S., F.L.S., F.G.S.
Henry Hicks, Esq., F.G.S., F.R.C.S.
Prof. T. Rupert Jones, F.R.S., F.G.S.
Henry Woodward, Esq., F.R.S., F.G.S., &c.

TREASURER.

F. G. Hilton Price, Esq., F.G.S., F.R.G.S., M.A.I.

HONORARY SECRETARY.

John Foulerton, Esq., M.D., F.R.S.E., F.G.S.

HONORARY LIBRARIAN.

John Hopkinson, Esq., F.L.S., F.G.S.

GENERAL COMMITTEE.

Rev. J. F. Blake, M.A., F.G.S.
Sir Antonio Brady, J.P., F.G.S.
Frank Clarkson, Esq., F.G.S.
Major Duncan, R.A., LL.D., F.G.S.
George Berringer Hall, Esq., F.G.S.
Captain Marshall Hall, F.G.S., F.C.S.
Wilfrid H. Hudleston, Esq., M.A., F.G.S., F.C.S.
William H. Leighton, Esq., F.G.S.
J. Logan Lobley, Esq., F.G.S., F.R.G.S.
Jeremiah Slade, Esq., F.G.S.
Prof. Jas. Tennant, F.G.S., F.C.S.
John Francis Walker, Esq., M.A., F.G.S., &c.

Mr. Carruthers having vacated the Chair, it was taken by the newly-elected President, Professor Morris, when the Thanks of the Association were given to the late President and to the late Honorary Secretary for their services, and the Annual General Meeting then terminated.

ORDINARY MEETING, February 2nd, 1877.

Professor Morris, F.G.S., President, in the Chair.

The following Donations were announced :—

"Abstracts of the Proceedings of the Geological Society," Nos. 324, 325, and 327 ; from that Society.

"Journal of the Society of Arts," January, 1877 ; from that Society.

"Catalogue of Mammalian Remains," by Sir Antonio Brady ; from the Author.

"On the Permians of the North East of England," by E. Wilson, F.G.S. ; from the Author.

The following were elected Members of the Association :—

H. G. Gardener, Esq., F.G.S. ; William Gifford, Esq. ; Miss Hester Green ; Oswald M. Prowse, Esq., ; Charles Joseph Wilson, Esq.

A large number of specimens (with microscopes) having been brought by Members for exhibition, the meeting, after explanatory remarks by William Carruthers, Esq., F.R.S., and other exhibitors, resolved itself into a Conversazione, during which the following microscopic and other objects were inspected :—

Sections of Coal Plants, exhibited by the late President (W. Carruthers, Esq., F.R.S., F.G.S., &c.) :—

Filices—Petiole of Frond under Mr. B. B. Woodward's microscope.
Group of Sporangia filled with spores.

Equisetaceæ—Fruit. Section of cone with spores.
Section of stem of Calamites through the Internode.

Lycopodiaceæ—Section of Stem of Lepidodendron.
„ Leaves of same.
Fruit. Cone with Macrospores.
„ Cone showing Microspores.

Section of Charnwood Forest Rocks, exhibited by Mr. Smith.

Spiculæ of Sponges from the Limestones and Shales in the Lower Carboniferous formations of Scotland ; exhibited by Dr. Millee.

Two trays of leaves (*N. O. Smilaceæ*), containing four species—three from the Bagshots of Bournemouth and one from Alum Bay, Isle of Wight.

One tray of small *Nautili* and two large specimens from the London Clay, North Western Railway Tunnel, Primrose Hill ; exhibited by G. Starkie Gardener, Esq., F.G.S.

Collection of Minerals; also Polyzoa, Cytheresæ, and Spicules of Sponges from the Carboniferous of Scotland; exhibited by S. H. NEEDHAM, Esq.

Left shed antler of *Cervus tarandus*, left ramus of the inferior maxilla of *Bos primigenius*, and scapula of same, from the Thames Valley gravels, South Kensington; exhibited by R. W. CHEADLE, Esq., F.G.S.

Belemnites tertiaria and *Salenia*, from the Miocene beds of Australia; exhibited by the Rev. J. F. BLAKE, Esq., M.A., F.G.S.

Land and Freshwater Shells from the Holy Land, Lignite from Loam-pit Hill (section of), Section of Sarsen Stones and prisms of *Trichites nodosus*; exhibited by W. H. LEIGHTON, Esq., F.G.S.

Post Pliocene Mammalia from Grays Thurrock; exhibited by C. WHITE, Esq.

Sections of Rocks and Minerals, consisting of Quartz with cavities and enclosures, Chalcedonies, Agates. Felspars, triclinic and monoclinic, and typical forms of Rocks; exhibited by F. W. RUDLER, Esq., F.G.S., M.A.I.

Fossil Wood from London Clay, Diploxylon from Arran, Dictyoxylon from Oldham, and Microspores of Truffle; exhibited by H. E. FREEMAN, Esq.

Dictyoxylon; exhibited by Mr. NORMAN.

Macrospores in Coal, Section of the Bradford Better-bed coal, and of brown Australian coal; exhibited by J. T. YOUNG, Esq., F.G.S.

Sections of the tooth of *Dendrodus* from the Old Red Sandstone, *Lamna elegans* from the London Clay, and of *Cochleodus* from the Carboniferous; exhibited by J. SLADE, F.G.S.

Sections of the brown part of a green-coated flint from the Bull-Head bed; thin chip of a transparent black flint, stained by nitrate of silver; and of the white outer coat of a flint from the Chalk; exhibited by M. HAWKINS JOHNSON, Esq., F.G.S.

Myaconcha longirostris, from the Inferior Oolite of Sherborne (Buck. MSS.); exhibited by H. TRYON, Esq.

Right ramus of inferior maxilla of *Labyrinthodon Lavisi* (Seel.); also anterior thoracic plate, a chevron bone, a scute and other bones of the same animal; the lithographic plate of them from the "Quarterly Journal of the Geological Society," and a water-colour sketch of the section of the Trias of South Devon, between Ladram Bay and Sidmouth, from which the above specimens were obtained, executed by P. O. Hutchinson, Esq. A collection of flint chips, flakes, and scrapers from Reading, and some flints, with deposits of Orbicular Silex on their surfaces, from the same locality; exhibited by H. J. JOHNSON LAVIS, Esq., F.G.S.

The Geology of Brighton. Part II.

By James Howell.

(Paper read July 7th, 1876.)

In the First portion of this paper, published in the Third Volume of the "Proceedings," page 168, after a description of the physical features of the district, and an historical account of recent modifications of the coast-line, the Recent Deposits, the Post Pliocene Brick-earth and the Coombe Rock or Elephant-bed are described. The Second portion of the paper will be devoted to the consideration of the Temple Field Deposit and the Eocene beds of Furze Hill.

Temple Field Deposit.

The Temple Field, named from the Temple School standing upon this site, was, during my first recollections, arable land with a hedge at its eastern extremity running parallel with a path leading over the hill and through Lovers' Walk to Preston. Within this field lay some fine boulders of Druid-sandstone, and which, with others then lying in a field nearer the Old Church, now form the base of the Victoria fountain upon the Steine. The waterworn conglomerates scattered everywhere about the Downs. Whence came they? Let us see. At the base of the Tertiary strata at Newhaven, with one bed intervening between it and the Chalk, lies a hard conglomerate of the thickness of a foot, consisting of shattered flints, pebbles, and sand, strongly impregnated with iron, and at the opposite end of the bay, at the commencement of the Chalk cliffs at Seaford, lying under a thick bed of sand belonging to the Woolwich Series, the same conglomerate attains a thickness of four feet. Probably the formation of this curious deposit took place in a shallow sea upon the Cretaceous strata, which would be covered with shattered flints mingled with pebbles and sand and clay and iron-stone, the latter cementing the heterogeneous mass into a hard conglomerate at the period when the Cretaceous strata were gradually sinking beneath the sea to receive the sands and clays of the Lower Eocene. Something akin to this came under my observation last summer, near Bembridge Point, Isle of Wight, where water charged with carbonate of iron oozing out of the Eocene cliff capped by a Pleistocene deposit, flowed seaward over a sparse beach, which in one or two places it had welded together into a conglomerate or pudding-stone, evidently increasing in size day by day, and which I watched with intense

interest. Now having seen this curious conglomerate scattered over the surface of the Downs, and lying *in situ* at the base of the Tertiaries at Seaford and Newhaven, let us turn our attention to the Temple Field, now covered with handsome edifices, viz., Denmark Terrace, St. Michael's Place, Powis Road, Victoria Road, Clifton Hill, part of Clifton Road, Montpellier Crescent, and Vernon Terrace. The same deposit can also be traced on through Cobden Road to Stanford Road, Prestonville, the latter being the site mentioned by Mr. Montague Phillips, when he says, "the Furze-hill deposit crops out where the Lovers' Walk commences, on the way to Preston." Thus it will at once be perceived that the Temple Field lies at the eastern extremity of the Hampshire or Eocene basin, extending from Dorsetshire to Brighton, Church Hill forming its eastern rim, whose summit, with few exceptions, together with its southern and eastern declivities, consist of Chalk with flints, while the Temple Field deposit extends down its western and northern slopes, and in some places penetrates to its usual depth 16½ feet on the crests of the hill in the form of a wedge, with its apex downwards, into the very core of the Chalk, giving one the idea that the latter had been scooped out, and this deposit washed into the hollow. These wedge-formed hollows in the Chalk were met with during the excavations in several places. Now upon this verge of the Hampshire Basin, a geologist might expect to find the wrecks of the Lower Eocene strata, as well as in the Hove level below it, their rich loams converted into brick-earth, succeeded by sand reposing upon the Chalk, and such is the fact. The various members of this deposit vary considerably in different places as regards thickness. The following section was displayed at the bottom of Clifton Hill :—

1. Rich brown, dark grey or ochreous loam, shivered flints, and seams of sand	3 feet.
2. Clay or Brick-earth	4 to 6 feet.
3. Breccia and ironstone, with clay, chalk, rubble, rotten flints, sub-sulphate and hydrate of alumina, succeeded by ochreous loam, containing brecciated masses of indurated clays, gypsum and flints spangled with crystals of selenite, curious stone with a metallic ring containing dark seams of selenite somewhat resembling veined marble, and ferruginous chalk rubble	7 to 8 feet.
4. Chalk with flints, the upper portion iron-stained, from	3 to 4 feet.

(1) The soil is very thin, some having being removed to form the road which is constructed upon artificial layers of chalk, which have a curious appearance lying as they do above instead of under the loam, the latter reaching in some places to the depth of several feet. It is generally of either a chocolate or ochreous colour, but in places assumes that of a dark-grey, containing immense quantities of shivered flints. Here and there in this deposit, but more especially in Clifton Road, the workmen discovered thin seams of silver-sand, specimens of which are preserved in our Town Museum. This sand, a remnant of the Eocenes, had probably been bleached by water percolating through it, charged with acids derived from the vegetable soil. Both the chocolate and buff-coloured loam contain rotten granules in it resembling chalk, which, on being subjected to atmospheric action, crumble into a fine ochreous powder. Iron, without doubt, has played an important part in its formation. The vegetable soil and decomposing iron pyrites form sulphuric acid, which, percolating into the Chalk, converts it into gypsum. May not, therefore, this deposit in many places be a gypseous marl, which coming in contact with the atmosphere imbibes carbonic acid which drives out the gypsum, and re-converts it into its original substance? When digging the foundation of the Congregational Church, at the corner of Clifton and Dyke Roads, the workmen laid bare a fine section of this deposit, and the Chalk beneath it. Lying in the loam was a brecciated mass of ironstone, and a rich vegetable soil above it, whilst immediately beneath it was a vein of what appeared to be hydrate of alumina, descending through the hard chalk to the very base of the foundation, and probably beyond it; but though the eye could not detect the difference, chemical analysis might prove the substance to be lime, for it looked as if a stream of water percolating through the soil and ironstone had deprived the chalk of its carbonic acid. This was most probably "Hovite," a carbonate of lime and alumina. There are specimens of this water-work everywhere throughout the deposit, leaving relics of its progress down into the very core of the Chalk.

(2.) Clay or Brick-earth of a reddish-brown colour, and extremely plastic, mixed with minute granules of chalk and flint. According to Mr. Godwin-Austin, brick-earth owes its origin to sub-aerial action, its most usual character being that of the wash of a terrestrial surface under a far greater amount of annual rainfall than

we have at present. It is a curious fact that this deposit should be several feet in thickness down the western slope of the hill, while it is scarcely anywhere found on the eastern slope into the Brighton valley, where Coombe-rock takes its place. Whether this Temple Field clay, however, is a real brick-earth, is doubtful. I imagine it to be a much older formation than that lying in the Hove Level. I extracted several lumps in its plastic state, lying at the depth of ten feet beneath the surface, and rolled them into balls, which are now scarcely distinguishable from the lower portion of the superincumbent loam.

(3.) This is a confused mass of chalk-rubble, clay, ironstone, breccia, sub-sulphate and hydrate of alumina, rotten flints, gypsum, brecciated masses of indurated clay, and flints spangled with crystals of selenite, ferruginous chalk-rubble, with beds of ochreous loam descending in wedge-like hollows of the Chalk, &c. At the bottom of Clifton Hill, near its junction with Montpellier Road, the breccia lay in immense quantities. Some idea of this may be obtained from the fact that from Montpellier Road to St. Michael's Place the breccia extracted from excavations two feet six inches in width lay piled up like a wall to the height of five feet. Much of it seemed to have undergone intense chemical action, so as scarcely to be distinguishable from "slag." This occurred in masses weighing several hundred-weights, dug up at a depth of 15 feet from the surface. The breccia was composed of angular and rolled flints, indurated clay and sand cemented by iron, and resembling in character the stratum lying *in situ* at Seaford. The whole of it was purely a conglomerate, for not a single sandstone was found throughout the excavations in this locality. This breccia or pudding-stone, the remnants of the foundation of the Eocene, is by many confounded with the Grey Weathers or Druid Sandstone, possibly derived from the Wealden strata, probably from the Bagshot Sands. The ironstone containing a large percentage of iron was scattered confusedly everywhere about the deposit, except at the north-east extremity of Montpellier Crescent, where the excavations reached 28 feet, for here, at the depth of 11 feet, occurred a vein of ironstone from 10 to 12 inches thick, of which I procured specimens, as it seems to be playing a most important part in the decomposition of the Brighton Chalk.

SUB-SULPHATE AND HYDRATE OF ALUMINA.—Half a century has passed by since Mantell discovered among some gravel lying

on a wharf at Lewes a curious mineral, and one which was a stranger to him. The gravel in which he found it was brought from Newhaven. A few months afterwards, as Mr. Webster was rambling along the Sussex coast, he collected a specimen of this mineral at Newhaven, which, upon being analysed by Dr. Wolaston, was found to consist of alumina in combination with sulphuric acid, and a small proportion of silica, lime, and oxide of iron. By many it is called *Websterite*, deriving its name, like America, from the second, and not from its first discoverer. It occurs in the last Tertiary layer in Newhaven cliff, viz., ochreous clay associated with gypsum, resting upon the Chalk, the superincumbent bed being breccia impregnated with iron. Up to 1851 Newhaven, and Halle, in Prussia, were the only localities in which it had been discovered, but in this year, as previously stated, Mr. Montague Phillips found a thin seam of it in relics of Eocene strata on the site of Stanford Villa, Prestonville. From this period to 1870 it was discovered in two or three localities in France, and was considered of rare occurrence. But the fact is, that it may be found plentifully distributed about the Chalk districts wherever clay, pyrites, or ironstone are superimposed upon the Cretaceous strata. As Mantell happened to find it at the base of the Lower Tertiaries, he very naturally concluded it to be a member of that series, but in many cases it is found not even associated with a single member of those beds, but deeply imbedded in the very core of the Chalk.

In the summer of 1870, I received a visit from a friend, Mr. Spencer G. Perceval, who held in his hand a piece of this snow-white mineral, with which I had been familiar from the days of my boyhood, though ignorant of its real nature. I immediately accompanied him to the spot where it was found in the Temple Field, descended the excavations, and walked along the tunnel some hundreds of yards, minutely examining the wondrous deposit around us. Promiscuously blended were slag and ironstone, breccia and gypsum, broken flints and masses of aluminite, as if the glacial plough had rooted them up, and the glacial crusher had passed over them, for the very foundations of the Tertiary world were turned topsy-turvy, and mingled with the wrecks of the uppermost bed of the Chalk. There were different varieties of aluminite in this deposit, milk-white and very friable, straw-coloured, hard, soft, heavy and light, and one pretty specimen, picked out of the clay in Clifton Road, with a straw-coloured

coating having the appearance of allophane. Horizontal seams of the white variety had penetrated through the flints, which, when touched, crumbled into fragments. A beautiful compact variety was found in Clifton Road having the appearance of old ivory, and in the centre of the specimen was what appeared to be a dark shining flint. That scientific enchanter, Manganese, had no doubt been trying his glamoury to produce this deception. But the most singular specimen of this mineral was found almost upon the surface of the Chalk about one foot beneath the road at Powis Villas, being moulded like the trunk of a tree, and the bark or coating resembling lignite. Mr. Perceval, in his article "On the Occurrence of Websterite at Brighton," thus describes it:—"The general appearance of the mineral was highly suggestive of a vegetable origin. Pieces with the rind attached, and having a fibrous structure, much resembled portions of a gigantic cocoa-nut. Two specimens were obtained from the same place, which have been secured for the Brighton Museum; they were mistaken for the stems of fossil trees, being in the form of a trunk, and described as 'six inches in diameter, the bark changed into lignite, and medullary rays diverging from the centre.' The substance on the exterior of the specimens, which so much resembled lignite, has been examined by Dr. Flight of the British Museum, and has been found to consist of manganese with a certain proportion of cobalt." The specimens alluded to were portions broken from what had every appearance of being the fossilised trunk of a small tree, several feet in length. Manganese it was which mystified and deceived me, as it has once done since by delineating foliage upon a Wealden sandstone. Vegetation and crystallisation have a closer relationship than many of us deem. Sub-sulphate of alumina is not, as it is supposed to be, a scarce mineral. In the railway cutting leading to Hove, it may be seen in every direction lying immediately below ironstone, embedded in clay resting upon the Chalk, and so throughout the Chalk in and around Brighton.

The late Mr. Montague Phillips and myself have often conversed together by the chalk-pit upon the incline leading into Goldstone Bottom, and yet that very pit contained cart loads of this mineral, although it is only twelve months since that my attention was directed to it by a pupil, who knew the substance from seeing it in my house, telling me there were immense masses of it in this chalk-pit. Upon visiting the spot, I found it, as usual,

associated with iron and clay. Rain-water, charged with sulphuric acid and iron, has percolated through these beds, staining the Chalk, and therefore revealing its sinuous courses through it. The massive variety of Websterite, or more probably, hydrate of alumina, is enveloped and intersected by these sinuous streams, but seldom the stem-like variety. An immense mass of the former bulges out of the Chalk stratum, and measures vertically 6ft. 6in., and horizontally at the base 7ft. This is traversed in every direction by veins of a soot-like substance, probably manganese, decomposed by subäerial action. Over these lies a friable layer of yellow Chalk, undergoing the process of formation into gypsum, and which on the application of sulphuric acid slightly effervesces. Resting upon this is a mass of ironstone and ferruginous clay, oxydised to its very core, and this is overlaid by chalk-rubble and vegetable mould. The stem-like variety, beautiful specimens of which are preserved in our Museum, and whose coating of manganese and cobalt so much resembles bark, is well represented in this pit. Some of these might be mistaken for petrified trees. They average from 2½ to 8 inches in diameter, and are of circular, oval, or irregular form. Many of these specimens showed no signs of the presence of either clay or percolations of water charged with acids in their vicinity. Being thus isolated from these substances, the question is—how were they formed? In the same state of isolation, deep down into the Chalk, and running parallel with it, were veins of aluminite and clay, and the problem to solve is—how did the clay get there? In flints there is a small percentage of clay and iron. Does sulphuric acid, formed from vegetable matter in the soil or decomposing iron pyrites, percolating through the Chalk, transform this clay into sub-sulphate and hydrate of alumina, or is there enough clay in the Chalk itself to form these substances? If so the process would account for the shattered condition of the flints. Probably what Prof. Morris mentions in his notice of allophane, may also apply to these flints: that, having been crushed, the aluminite re-cemented them. When aluminite is embedded in clay, chemistry clearly reveals its origin; but when, on the other hand, it lies isolated in the Chalk, where there are no faults or fissures to account for its presence, then its formation is a difficult problem to solve. Since this was written, most of the aluminite alluded to in the Goldstone Bottom chalk-pit has been removed, and the pit now displays a fine section of the Cretaceous strata. The mineral lying in the core of the Chalk in this pit is not aluminite, but "*Hovite.*"

It was discovered and analysed by Mr. George Gladstone, and named by him "hovite," from the pit being situated in Hove. It is a carbonate of lime and alumina, and not a sulphate. The eye, however, can detect no difference between the two minerals.

IRON ORE, CHALK, AND GYPSUM.—Much of the iron ore throughout this deposit is in a state of decomposition, very friable, and of a cindery appearance. Some of the heaviest masses of this ore are punctured with holes filled with a fine ochreous powder, probably an oxide of iron, which gives to the whole heterogeneous mass its ferruginous appearance, and plays the most important part in the decomposition of the Chalk strata. In every locality where this peculiar Temple Field deposit lies, the fissures or holes in the Chalk seem to have been caused by the decomposition of the Chalk itself, water charged with acids and carbonate of iron being the prime agents of the disease. The same idea seems also to have occurred to Mr. Perceval, when he says, "The deposit of Websterite is about three feet wide at its junction with the overlying ferruginous mass, narrowing as it descends, apparently occupying a fissure in the Chalk, which has at some time been filled with clay, or has been formed by some decomposing action on the Chalk." To me not a single hole had the appearance of having been scooped out and then filled with clay, but in every case the result of the latter process. One of these holes was met with in digging the foundations of All Saints' Church, and occasioned great expense. Nor do I believe after all the money spent upon it the foundation to be permanently secure, for so long as the agents of this chalk disease are present above the Chalk, the disease will gradually eat into its core, and render any building above unstable. It is like cancer in the human system, for which, if not wholly rooted out, there is no cure. But, in another respect, it is a blessing, metamorphosing, as it does, the barren chalk into a fertilising soil, and thus giving to the inhabitants of the Downs what they so ardently long for, a few trees, with their grateful shadow. Wherever this deposit presents itself trees take root and flourish, as in the Montpellier district, and at the copse on the Dyke-road, &c. One of the largest holes in the Chalk, filled with this deposit, was cut through in Montpellier Road, opposite the north-east extremity of the Crescent. Eleven feet beneath the surface lay the vein of ironstone already alluded to, in an ochreous mould, light and dry as the finest dust, probably an oxide of iron, which descended in the form of a wedge to the bottom of the excavations, 26 feet, and no

doubt much deeper. Within it lay several masses of curious formation, having the appearance of blocks of chalk converted by chemical action into a stone containing iron, gypsum, and dark green crystals of selenite in horizontal seams, which gave it a resemblance to veined marble. One large mass contained three casts of *Inoceramus*, showing that the substance must have originally been Chalk. The dark grey colour and the dark seams of selenite may be owing to the presence of bitumen. The roots of the trees in the garden of Montpellier Crescent had ramified into the loam in every direction, but not one of them had penetrated into the Chalk. Much of the ferruginous breccia had a cindery appearance. Other specimens resembled honeycomb, suggesting the idea of water charged with acids dripping upon and eating into it. The cores of other specimens of gypsum or indurated clay, with crystals of selenite, seemed eaten out, probably by this water action. Crystals of selenite abounded in some of the ironstone breccia, while limonite was plentifully represented throughout the whole deposit. Some specimens seem to have undergone intense chemical action, as if the substance of which they were composed had bubbled up and the gas had escaped, leaving innumerable orifices upon the surface, coated with a coaly substance, or tinged of a yellow green and violet hue, the unbroken bubbles being botryoidal and reniform. Pretty silver-like crystals adorned the smooth surface of the flints, sometimes assuming the frosted appearance seen upon our window panes. Other specimens sparkled as if diamond dust had been scattered over them. Some of the crystals were flat and broad, some needle-shaped, others filled the interstices of the gypsum and indurated clay with cobweb forms.

Ferruginous Tabulated Flint.—At the junction of Clifton and Dyke roads were found masses of ferruginous flint, flat and coated with a covering of chalk, giving one the idea of a stream of silica and iron becoming solidified at the bottom of the Cretaceous sea. It had every appearance of a silicate of iron. Chemical analysis proves that silica is soluble in water, and that it has an affinity for organic substances into whose composition it enters. That the process is a simple one there is little doubt, but in these tabulated masses I was unable to detect any organisms to attract and precipitate the silica held in solution by the water. What hidden cause effected this end? Did the infusoria create these tabulated ferruginous masses of silica? The presence of silica in bog iron ore, and the incombustible organic structure of the very

small corpuscles which form the surrounding ochre, make it, as Ehrenburg remarks, "very probable that here also an organic relation by infusorial formation comes into play, so that these animalcules, after their death, form a nucleus towards which the dissolved iron immediately around is attracted." Specimens of this yellow deposit were examined microscopically by Mr. Wonfor, Honorary Secretary to the Brighton and Sussex Natural History Society, who could discover no trace of *Gaillonella*, or the least signs of any organisms. There are many facts which prove the solubility of silica in water. Reeds and rushes thrive luxuriantly in ditches plentifully supplied with fresh streams of water. If silica is only soluble at a very high temperature, how is it derived by the stalks of corn and grasses from the flinty soil of our Downs? Nature has a more simple process in her wondrous laboratory to effect this than we have. Liebig tells us that, after the destruction of a hay-rick by lightning in a meadow between Manheim and Heidelberg, there was found upon the spot where it stood a glassy mass consisting of silicate of potash. "If (says Bischoff) the silica, instead of being introduced into hay or straw, were deposited as a quartz layer, it would, in 78,705 years, acquire a thickness of one foot, and the formation of the most enormous quartz layers may be accounted for in this way."

Gypsum: its Origin.—These excavations through the Temple Field clearly reveal one fact, viz., that the heterogeneous mass there confusedly mingled was derived from the beds of Plastic Clay once *in situ* in that locality; and not only there, but upon the highest summits of our Downs, where the loam still lies several feet in thickness. The denudation of the Lower Eocene, whose strata form this deposit, must have been by the waves of the sea, the tumultuous rush of mighty waters, or the glacial plough, for the breccia which lay upon the Chalk in compact beds several feet in thickness has been torn up, hurled over the surface of the Downs, or roughly mingled with the soil, loam, clay, and chalk-rubble, as witnessed in the formation we have feebly attempted to describe. The ruin is so complete, or the deposit is of such chemical origin, that not a single fossil has been found imbedded in it. Even the lignite of the Plastic Clay has entirely disappeared, unless traces of it are still visible in the coaly variety of the indurated clay, breccia, and gypsum. Mention has been made that the curiously-formed substance having a metallic ring, bore distinct

impressions of shells of the Cretaceous epoch. How then, was the chalk, for chalk it must have been, converted into gypsum? What is the origin of gypsum and crystals of selenite, chalk being a carbonate and gypsum a sulphate of lime? As infiltrations of carbonate of lime convert sand into sandstones, and Chalk corals and shells into limestones, so will infiltrations of sulphuric acid convert chalk into gypsum. Wherever water, then, percolates, holding sulphate of lime in solution, there must be gypsum; and, should the water evaporate, leaving a gas, sulphuretted hydrogen, then, wherever that gas penetrates, be it into clay or sand, into breccia, gypsum, shells or flints, there will be crystals of selenite. Bischoff, in his "Elements of Chemical and Physical Geology," says:—"The formation of gypsum from limestone in the neighbourhood of exhalations of sulphuretted hydrogen, is a very common phenomenon. Breislak brings forward many examples of such a formation from sulphur springs. In 1823 Cornelli found very curious crystals of gypsum and sulphur in the crater of Vesuvius, originating from the fumaroles. Dumas has shown that even the most minute traces of sulphuretted hydrogen convert limestone into gypsum. He found no free acid in the fumaroles of Tuscany, and yet the carbonate of lime in their neighbourhood was rapidly converted into gypsum, which could only be owing to a minute quantity of sulphuretted hydrogen in these vapours. He observed a similar phenomenon in the sulphur baths at Aix. The limestone walls of the saloons and bath rooms blister, and become covered with crystals of gypsum." Need we wonder, after this, at the production of sub-sulphate and hydrate of alumina, gypsum and crystals of selenite, in the Temple Field deposit? Nature works by simple laws, and the results are truly wonderful. A great portion of the soil owes its origin to decomposed vegetable and animal organisms and iron pyrites. In this soil, therefore, is sulphuric acid, which is conveyed by rain water down to the clay, ironstone, and Chalk through which it percolates, and metamorphoses the clay into sub-sulphate and hydrate of alumina, and the carbonate of lime into sulphate of lime, or gypsum, and crystals of selenite. In the clay and chalk rubble lie breccia and ironstone, spangled, by the union of sulphuric acid and lime, with crystals of every variety of form and colour. Such are the characteristics, and such is the origin of this Temple Field deposit, lying from 160 to 220 feet above the mean tide level of the sea, which rises and falls upon this coast 20 feet.

ORDINARY MEETING, March 2nd, 1877.

William Carruthers, Esq., F.R.S., Vice-President, in the Chair.

The following Donations were announced :—

"Quarterly Journal of the Geological Society," Vol. xxxiii. Part 1 ; from the Society.

"Abstracts of the Proceedings of the Geological Society," Nos. 328 and 330 ; from the Society.

"Transactions of the Manchester Geological Society," Vol. xiv., Parts 6 and 7 ; from the Society.

"The Royal School of Mines Magazine," Vol. i., Nos. 1 and 2.

"Journal of the Society of Arts," February, 1877 ; from the Society.

"The Val d'Anniviers," by Marshall Hall, F.G.S. ; from the Author.

The following were elected Members of the Association :—

Richard Barker, Esq. ; William Robert Cheadle, Esq. ; William H. Davis, Esq. ; N. Heinemann, Esq., Ph.D., F.R.G.S. ; William Ford Stanley, Esq., F.R.A.S., F.R.M.S.

The following Paper was read :—

History of the Restoration of Extinct Animals.*

By the Rev. J. F. Blake., M.A., F.G.S.

Since the earlier restorations of the extinct forms of life—amongst which those by Professor Owen, exhibited in the grounds of the Crystal Palace, are the most prominent—a considerable acquisition has been made to our knowledge of many among them, which has, in some instances, made considerable alterations necessary ; while other forms of life, though playing an important part in the past history of the world, have never been presented to view as they may be supposed to have been seen in a living state. It seemed, therefore, that there was room for new attempts at restorations which should embody our knowledge up to the

* The Pictorial Restorations referred to in this paper, were exhibited by the aid of the Oxy-hydrogen Light.

present date; and having made such attempts, I now bring these restorations before the Members of the Geologists' Association, that those who might be specially conversant with particular types might offer their criticisms upon their supposed appearances during life. The forms selected are for the most part so well known as to their general characters, that a mere delineation of them, or a discussion of their rank in the animal kingdom, would be superfluous; but an account of the history of our knowledge of their nature, our mistakes, and their gradual, if they are even now complete, correction cannot fail to be of interest. The first form selected for illustration is that of the

I. GRAPTOLITES.—When these were first noticed in Sweden by Bromel, in the year 1727, they were not unnaturally, perhaps, supposed to be leaves, under which idea they received their name from Linnæus. In 1821, Wahlenberg, though for the first time considering them as animals, was very far from the mark in classing them with the *Orthoceratites*. Brongniart, in 1828—as was perhaps natural in a botanist—again claimed them as fucoids; but shortly afterwards, Nilsson (1830), observing them in the original country, came to the conclusion that they were hydroid polypes—a location which, perhaps, even now, cannot be improved upon. It was not until nine years later that they were first noticed as British in the "Silurian System," when they were associated with the Pennatulids. With these they certainly agree in their, at least partly, free swimming habits; but the cells of the graptolites have no homologue in any hard part of the pennatulids. Portlock, in 1843, again returned to Nilsson's idea; but Salter, later, made another guess by comparing them to the Polyzoa. If it be true, however, that the cups of the graptolites really communicate with the hollow stem, they exhibit the character of the hydroids, with which they also agree in possessing special reproductive capsules. The great difference between these and their modern congeners consists in their habits; the Graptolites were obviously in most cases free, and they are so represented in the restoration; while some were permanently fixed like the *Sertularia*, or sea-fir, with which we may best compare them. No doubt, their numerous tentacles would, in the former case, be an efficient aid in locomotion.

II. ENCRINITES.—Fragments of the stony framework of this class of animal have been known from time immemorial, having

attracted attention by their remarkable shapes and ornaments, and were called Entrochi, Astroites, Star-stones, and St. Cuthbert's beads. They are not properly speaking an extinct form of life, as numerous living examples are now known in many parts of the world, but they are of a class with which we have become perfectly familiar as fossils long before any recent representatives were found. The earliest known living specimens were procured off Martinico in 1761, and they were described with special reference to their interesting relationship to the well-known star-stones, by Guettard in Paris and by Ellis in London. Their connection with the *Comatula*, or feather-star, was subsequently demonstrated by the discovery of a young form of the latter, which, like the true *Pentacrinus*, was fixed to the ground; and living adult specimens of animals of this order has since been discovered by Sars and subsequent deep-sea dredgers. They are represented in the restoration as stretching out their stony arms, and gracefully bending their slender stems as they search for food, or are moved by the currents.

III. Trilobites.—The earliest recorded specimens of this order are those found by Lhwyd in 1698 at Llandeilo—a still prolific locality. He compared them to flat fish. The celebrated limestone at Dudley yielded them subsequently in such abundance that they were called "Dudley locusts." Their true relationship was first indicated by Linnæus, who placed them with the woodlice. Unfortunately only their upper surfaces were for a long time known, if even now we can say we know much more, so that it could not be settled whether they had legs beneath, which would associate them with the *Isopods* or woodlice, or only swimmerets and breathing organs, which would draw them nearer to the *Phyllopods*. Doubtless they are a group which has peculiarities not to be matched in any other; but the discovery by Billings, in 1870, of what appeared to be legs in an *Asaphus* from Potsdam, has led to their closer association with the Isopods, though it has been objected that the so-called legs may be but the bases of support for the swimmerets. Trilobites of various types from the Silurian beds are represented in the restoration; some coiled up as they are often found, and some swimming. Some, at least, ought to be represented as floating back downwards.

IV. Eurypterus.—This is the type of a family of Crustaceans of so peculiar a character that no one but such as were fairly compe-

tent judges attempted to point out its affinities, and, consequently, but comparatively few mistakes have been made about it. The earliest recorded specimen was found in America by Dekay in 1825, and was at once called a crustacean allied to the branchiopods. Six years later they were discovered by Mr. Scouler in flagstones of Old Red Sandstone age at Arbroath. Agassiz, for some time, confounded them with fish—another example of how each specialist claims all problematical fossils for his own domain—but afterwards he recognised their true affinities. From their strange appearance they are called "Seraphim" by the Scotch quarrymen. The restoration, embodying the last results of Mr. Henry Woodward's researches, comprise the two most notable forms of the family, viz., the *Eurypterus*, with no claws and a long tail, and the *Pterygotus*, with large claws but a short tail. They attained a large size, and frequented sandy shores, crawling on the ends of their arms and supported by their tail, if we are right in referring to them the marks on sandstones called *Protichnites scoticus* and *T. notatus*. Considering their very peculiar characters, their range in time is most extraordinarily limited, being confined to the Upper Silurian and Old Red Sandstone, and being remarkably coeval with the *Cephalaspids*—a peculiar type of fishes to be afterwards noticed—to which alone they have any external resemblance, except to the representatives of their nearest living allies, the Limuli or King-crabs.

V. Belemnites.—If the last order of animals noticed have had but a short history, the Belemnites are very different in this respect. The wonderful pointed stones, like darts hurled into the ground, have long been the wonder of the curious. Noticed, doubtless, in extreme antiquity—the earliest definite mention of them after the invention of printing, is by Agricola, in 1546, who found them in Germany—but not till 1677 do we find any notice of English specimens, which were then described by Plot in his "Antiquities of Oxfordshire." They numbered them, however, among the figured stones, and while those which were seen to be like shells were dismissed as *lusus naturæ*, these, having no resemblance to anything known in the animal kingdom, were never thought to have any connection with it. They received various names, such as thunderbolts, devil's fingers, &c. The properties of their mineral substance were studied, such as their electricity, phosphorescence, and supposed curative properties when powdered.

Later they were compared to horns and teeth; and at last, when the inner shells or phragmocones were discovered, their relations to the *Nautilus* began to be perceived, though the well-known Belemnite or guard was then thought to be an extraneous overgrowth to the true shell. However, in 1764, their true nature was finally determined by Joshua Platt, in a valuable memoir in the "Philosophical Transactions." Since that time the progress in our knowledge of them has consisted in the demonstration of their possessing such parts as by analogy we might suppose them to have had. The earliest restoration of the Belemnite is that given by Buckland in 1829, and the present chiefly differs from it in representing them in an active state, and as making the known use of their ink-bag, which, with the funnel, hooked arms, and eyes, have all been discovered associated with the guard and its chambered shell. No signs of fins or sucking arms have been found in the true Belemnites. Their habits were doubtless those of the recent cuttle fishes.

VI. AMMONITES.—This is another form of animal whose remains have been known from time immemorial, even to the most careless observer of the rocks, and though its relation to the *Nautilus* was clearly seen, it is only during the last fifty years that that comparison conveyed any information, when a recent nautilus being dissected by Owen gave us an insight into the probable organisation of the Ammonite. Every one, of course, has heard of the legends connected with these fossils, which have survived in country parts in their common name of snakes. We are not, perhaps, certain even now of the true relationship of the Ammonites, but they are represented in this restoration with the incomplete funnel and numerous simple tentacles of the Nautilus, and possessing also what the latter is deficient in, viz., a shelly operculum. This operculum, under the name of *Aptychus*, has given more trouble than any other part about the animal, being supposed to belong to some separate species; but its nature was finally set at rest, or at least ought to have been, when Voltz, in 1837, found it accurately fitting the aperture as an operculum should do. In spite, however, of this and of its resemblance to the hood of the Nautilus, which has an analogous function, various other offices have been assigned to it, which are, however, rejected in the present restoration. The Ammonites were very possibly highly-coloured shells, which either crawled at the bottom of the sea on their tentacles or

floated in its neighbourhood; they probably inhabited deep seas, and there is no antecedent impossibility of their existing there still.

VII. Cephalaspids.—We return to a group with an exceedingly short history, dating no further back than 1835, when Agassiz first noticed them, and showed them to be fishes. The only erroneous ideas that have been entertained with respect to them are that of Kner, who compared the cephalic shield of *Pteraspis* to the "cuttle bone," and that of Romer who confounded it with crustaceans. The true bony structure of *Pteraspis*, however, was demonstrated by Huxley, in 1858. The restoration is founded on that of Ray Lankester in the Palæontographical Society's volumes, and denotes them burrowing in the sand, and so protecting their naked bodies and leaving exposed that part which was covered by a bony shield. It is very remarkable that their period of existence is limited almost exactly in the same manner as that of the Eurypteri, whose external form they so strangely mimic.

VIII. Labyrinthodonts.—The restoration of these remarkable and gigantic amphibians has been only accomplished by degrees, if it can be said, even now, to be complete. Their discovery dates back to the year 1828, when Jager named their teeth *Mastodonsaurus*, and their double occipital condyles *Salamandroides*. He afterwards found that these separate parts belonged to the same animal. It was not, however, until 1842 that they received their present name, from an examination by Professor Owen of the wonderful labyrinthic structure of some teeth which were found in the New Red Sandstone of Warwickshire. In the same beds were found the hand-like footprints, to which the name of *Cheriotherium* was given—and it is a very probable, though as yet unproved conjecture, that they were made by the animal which possessed the labyrinthic teeth. The arrangement of these footprints is so curious—one left, one small left, one right, one small right—nearly in a line, that it is difficult to imagine how the animal walked, unless he waddled from side to side, as he is represented as doing in the restoration. The creature to which these remarks refer was, undoubtedly, the largest of his kind—various other smaller forms having been subsequently referred to this Order. In several of these smaller ones, a well-marked tail is present. Since their discovery near Edinburgh, in 1862, and at Kilkenny, in

1867, it has been thought more probable that the *great* Labyrinthodon had also a tail, though it had previously been restored without one. No scales, or other dermal armour, have been found, so that we may suppose it to have been smooth-skinned like the recent Amphibia. It, doubtless, frequented the neighbourhood of still water, on the sandy shores of which it left its hand-like tracks.

IX. IGUANODON.—No extinct animal has gone through so many changes in its appearance as this during its many restorations, or has more gradually and completely unfolded its nature by its remains. Every geologist has heard of its early discovery by Mantell, in 1822, who sent the teeth and bones, which came to light in the Wealden beds of Tilgate Forest, to all the naturalists of his acquaintance, without much light being thrown on them and, at last, to Cuvier, who pronounced them to belong to an herbivorous reptile, to which Mantell gave the name by which it has ever since been known—from the resemblance of its teeth to those of the recent, but far smaller, *Iguana*. The next step was the discovery of large portions of its remains in the now called "Iguanodon Quarry," in the Kentish Rag, near Maidstone, in 1834, which gave a general idea of its structure, and especially proved that its hind legs were much longer than its fore, and that it had a large tail, supported by massive spines. The strength of its hinder quarters was further demonstrated in 1840, by Professor Owen, from the remains of the sacrum of five well-joined bones, in the collection of Mr. Saull. That it was possessed of fleshy lips was shown in 1848, by Dr. Mantell, from the vascular apertures in its lower jaw. But the nature of its feet—and, in particular, the meaning of one curious bone—which has turned out to belong to them, remained for a long time unknown. This bone is of a bluntly conical form, slightly unsymmetrical, and covered with vascular markings. To ascertain its nature, Dr. Mantell examined the recent allies of the Iguana, to find anything corresponding to it, and finding that one species of that genus possessed a horn on the end of its nose, forthwith came to the conclusion that the Iguanodon had one also—and thus located the unknown bone. For a long time then the Iguanodon went about horned, but the unsymmetrical character of the supposed horn led Professor Owen to doubt the correctness of this interpretation, and to suppose it might represent one of the unequal pha-

langes. This turned out, in 1871, to be nearer the truth. In that year Mr. Beckles exhumed, at Hastings, a complete fore foot, which at the same time showed that that limb was possessed of five toes, and that the supposed horn was not one of them. It was found, however, associated with the foot—inasmuch as it was attached firmly to the wrist, and immovable—forming, therefore, a spur, like that of the hind fins of the shark. That the hind feet possessed three toes had already been proved, in 1857, by a specimen from the Isle of Wight—where also the impression left upon the sandy shore, by its heavy tread, was exposed to view. The absence of any remains of scales in all the specimens showing associated bones, and the discovery of the impression of a smooth skin in the Isle of Wight, completes the materials for its restoration—and, however remarkable that restoration may be, it is scarcely at all conjectural. Whether it leapt like a bird—a strange task for a reptile 60 ft. long—or used its smaller fore feet in progression, is a still unsettled question. But that it was a harmless, vegetable-eating brute, roaming through the Wealden forests, and tearing up, it may be, the trees and smaller vegetation by its pointed spurs, there can be but little doubt.

X. Ichthyosaurus.—There is little, or rather nothing, to add to the restorations of this animal, seeing that perfect skeletons have long been known, and impressions of the smooth skin have long ago been found. It is represented as swimming in search of its prey, instead of unhappily stranded upon the shore, where it must have been ill at ease. Considering the perfection and commonness of its remains, it is remarkable how short a history it has had—perhaps, from the similarity of its vertebræ to those of fish, no notice has been taken of them. The earliest record of an Ichthyosaurus was that of a head, and some other bones, found at Lyme Regis, in 1812, and described by Sir E. Home, in the "Philosophical Transactions," as belonging to a fish. It was more correctly determined two years later by König, of the British Museum, who, recognising its affinities to the Reptilia, bestowed upon it the name by which it is at present known. The correctness of his ideas was proved in 1816, by the discovery of its scapular and pelvic girdles, and three years later it bounded into full light by the discovery of a complete skeleton. No doubt animals of considerable diversity of character are included under this single name—as there are great varieties of size—but,

probably, the habits of them all were alike. The tyrants they must have been of the ocean, the masters of all other inhabitants, but with the Cretaceous period of Europe they passed away for ever.

XI. Plesiosaurus.—This form of reptile, though perfectly distinct from the last, and probably of a higher grade of organization, has always been second in comparison with it. Even its name signifies that the other was discovered first, and that the last discovered was nearest of the two to the Saurians. So it must also have played a subordinate part in the waves of the ocean, where they both dwelt; its small head and less formidable teeth rendering it no match for the *Ichthyosaurus;* though, probably, it was more nimble. Remains of this animal, not at that time known by its present name, were found in 1818, in the Lias of Fulbeck, in Lincolnshire, at the base of the Oolitic escarpment, and they were viewed as evidence of the Flood, during which catastrophe the waters which flowed against the escarpment could not carry the remains of the animals it destroyed to the top, and so they accumulated at the base! It may be said to have been rediscovered in 1821, by Conybeare—from scattered bones at Lyme Regis. Next year the head was seen, and, in 1824, the whole skeleton gave to view the strange proportions of the reptile, and left no doubt of its general character. Greater changes than in the case of the *Ichthyosaurus* passed over this type of animal during its geological history, so that they have been considered worthy of being commemorated by different generic names. We may imagine them, perhaps, to have lain hid from their enemy the Ichthyosaur, in places where he would not willingly have come, and gliding about with their lissome bodies in search of prey, or raising their heads to the surface to breathe.

XII. Pterodactyl.—No class of animal has given rise to more discussion than this, and it is even now quite undecided by those who have paid most attention to them where they are to be placed, or whether they were warm or cold-blooded. Their general appearance, however, and habits, marvellous though they were, are too certainly known to be disputed. The earliest knowledge possessed of them was from remains discovered in the prolific quarries of lithographic slate of Upper Jurassic age at Solenhofen in Bavaria, from whence, to the present day, the most perfect skeletons are obtained, though under slightly modified forms they occur in much

older rocks, as in the Lias of Lyme Regis. Whether or not they required too tropical a climate, no remains of them have occurred in Yorkshire. Collini, who in 1784, described the first known specimen, considered it a marine animal, an easily disproved idea. Blumenbach thought it to be a bird, and Hermann, who, in making a restoration of it clothed it with hair, considered it a mammal. Its name is due to Cuvier, who believed it to be a reptile, so that it has at times been placed in all the divisions of vertebrates. Since the time of Cuvier, however, it has never been thought to be otherwise than either a reptile or a bird, or belonging to a Class distinct from any. That an animal with such a neck, such large and piercing teeth, such long fingers, and for the most part such an insignificant tail, should be called a bird, seems stretching a name indeed; on the other hand, its air-celled bones, so characteristic of birds, and the shape of its brain, seem to point strongly to an ornithic relationship; and since the discovery in the Cretaceous beds of America of undoubted birds with teeth, as also in the London Clay of Sheppey, one objection at least is diminished. On the other hand the air cells, like the keel which their sternum possesses, may be considered rather an adaptive than a generic character. Left, then, in doubt where to place them, we may leave them at present to their convenient appellation of "*Ornithosaurs*," proposed by Professor Seeley, and only further ask, was their blood warm or cold? On the ground that no feathers or other covering of the *Pterodactyl* have ever been found at Solenhofen, where the most delicate of organisms are often preserved, Professor Owen believes them to have been cold-blooded, because there is no provision made for keeping in the heat. Professor Huxley, on the contrary, has argued that such an active life must necessarily have generated heat in the body. This is doubtless true. Yet it does not follow that the heat was so long retained as to raise the temperature to that of birds or mammals. We have, therefore, here perhaps another character—their cold blood—which widely separates them from birds as we know them.

XIII. ARCHÆOPTERYX.—This strange bird is one of the most recently discovered of the relics of a former state of things, dating back only to 1861, in which year, after its presence had been indicated by a feather, the slab which contains its only known* remains

* Quite recently (1877) another specimen is stated to have been found in the same locality; of this we shall probably hear more.

was discovered at Solenhofen. This is now exhibited in the British Museum, but the trustees had to pay an enormous price for its possession, as the collection which contained it was sold at no less a sum than £950. The present is the first attempt to restore it. Its long tail makes not quite so conspicuous a feature as might have been anticipated; and the series of bones which make that tail so peculiar and reptilian were, to a certain extent, hidden by the feathers. Nor are the claws in the front of the wings long enough to strike the attention. It is not yet known what was the character of its head, though Mr. Woodward is of opinion that it had teeth. In the absence of any indication of the colour of its plumage, it is lawful to bestow upon it a bright and attractive appearance.

XIV. Dinornis.—In the year 1839, a fragment of a "long bone" which had been discovered in New Zealand, was sent to Professor Owen for determination. It was a very slight indication of the original animal, but he pronounced it to belong to a gigantic species of some struthious bird, and urged that more of such relics should be sought for. Accordingly, in 1842, a missionary named Williams collected a considerable number of bones, which enabled Professor Owen to make a further restoration, to which he gave the name of *Dinornis*. Stories were told by the natives that they had once seen this gigantic ostrich-like bird alive, and had called it the Moa. More than one story has reached England of living specimens having been seen, but they have hitherto proved delusions. Yet it is certain the animal has not been long extinct, for the series of remains which, since 1847, have been collected, first in 1859 by Mr. Walter Mantell, and afterwards by Mr. Hochstetter, continually introduce us to more perfect specimens in which not only is every bone perfect, but even the ligaments are left undestroyed. One such is in the Museum of the College of Surgeons, another in that of York, and quite an aviary of them in Canterbury, New Zealand. They have even been found in the posture as they died—the mother brooding her young as they were all buried in the sand. The bird was very similar to the ostrich, but of larger size, and the feet and legs very disproportionately developed.

XV. Dodo.—There is nothing new in the restoration of this bird, as our best knowledge of it is from an old Dutch painting, but it is so good an example of the extinction of a species, that

it has always been interesting to geologists, and as its history is not so easily got at, its presence in this series may be excused. We first hear of it in 1598, when a Dutch sailor, Van Neck, went to the Mauritius, and found there a fat, lazy bird, very good for food, of which he gives a very characteristic representation, as "Walck vogel," in one of his pictures. In 1602, Willem, another Dutchman, found them in abundance, and captured 40 or 50 of them. So fat were they, that two of them made a meal for all his crew, who surnamed them "Dodaarsen," or "Dodoor," meaning sluggard. A living specimen was finally brought to London, and exhibited in a show, as recounted by Sir Hamon Lestrange, who accuses it of the habit of eating stones. It is very probably the stuffed skin of this specimen that subsequently found its way into the Ashmolean Museum of Oxford, where its fate was but a bad one. It remained there for more than a hundred years, gravitating, as it grew dirty, to the cellars, till in 1755, it was ordered by the authorities to be destroyed as useless, though meanwhile the species had become extinct, and therefore of greatly enhanced value. Only a head was saved from destruction, which now forms one of the gems of the Oxford Museum. The last time that this bird was heard of alive was in 1681, when the sailors of the "Berkeley Castle" visited Mauritius; there were then plenty of them to eat, but whether the sailors finished them, or whether the few that remained were unable to resist the attacks of their enemies, certainly they were then or soon after exterminated, for, in 1693, a traveller describing the productions of Mauritius, made no mention of the Dodo, nor has it ever been seen alive since. Numerous bones, however, and several complete skeletons have been preserved, one of which stands in the British Museum near to the old Dutch painting of the bird, which is one of five that were made when it was alive. It stood about three feet high to its bill, and was probably an overgrown pigeon, a useful warning that size is not always a sign of vigour, but it may be of sloth, from the absence of enemies, and when these invaded the region it inhabits it suddenly disappears.

XVI. Palæotherium.—This is the only mammal, if we except the *Sivatherium* and some others not restored before, on which any new light has been thrown of late years. It was originally restored by Cuvier in 1806, at the same time as the *Anoplotherium*, which

occurs with it in the Paris gypsum-beds, but though fairly complete skeletons were at hand, it was always represented, as it is seen in text books, as a heavy, short-legged animal, with a stiff and short neck. A skeleton, however, discovered in 1873, in the same beds, showed the animal so naturally preserved, that there could be no doubt that its right position and form was thus indicated, which show it to be of graceful attitude, and to possess a long, curving neck, making it much more like a Llama than a Tapir, to which it had been previously compared. When the old skeletons, from which Cuvier drew his restorations are examined, it is seen that the graceful neck is there, but the bones have been pressed together, so as to obscure the natural appearance. It was the great difference in the appearance of this animal when restored according to the old and the new skeletons, that first led me to think of the advantage and desirability of having some new restorations attempted.

No doubt much has yet to be added before we can rightly people the buried ages with their true inhabitants, and the present contribution will show how it is often a slow work to which many successive labourers must lend their hands.

VISIT TO THE BRITISH MUSEUM.

(Australian Fossil Marsupialia.)

March 17th, 1877.

Director—Professor Owen, C.B., LL.D., F.R.S., &c.

(*Report by* Charles White, Esq.)

Proceeding to the Marsupial Case in the Mammalian Gallery, Professor Owen introduced the subject of the Marsupialia to the Members assembled, by submitting to their notice the largest specimen of the jaw of *Macropus major* which he had been able to obtain from his friends in Australia, at the same time drawing particular attention to the fact that this species of Kangaroo was the largest *living* Marsupial animal.

The Professor then proceeded to describe the dentition of the Marsupials, noting the peculiarities of the individual teeth, dwelling at considerable length upon the structure of the premolars, the prolonged study of which had enabled him to construct,

from the remains discovered from time to time, several extinct genera closely allied to the existing Kangaroo, some being of much greater size than the largest living *Macropus*. The following have thus been differentiated:—*The *Sthenurus*, with the pre-molar larger than that of the present Kangaroos; the *Protemnodon*, with a larger and more trenchant pre-molar—allied to the Kangaroo Rat; the *Procoptodon* with the pre-molar of a triturant type; and the *Palorchestes*, hugest of extinct Kangaroos, with generic modifications of the skull. These were successively dealt with, and the jaw of the *Macropus*, finally placed in juxtaposition with that of the fossil *Palorchestes* when the marked superiority of size of the extinct animal at once became apparent.

Professor Owen then proceeded to treat of the fossil remains of Marsupials allied to the existing Wombat. He next pointed out the evidences of the giants of the Marsupial order, viz., the *Diprotodon*, with its two large front teeth in the lower jaw, and the *Nototherium*, with a modified pre-molar and minor development of the inferior incisors. These he characterised as the pachydermatous type of Marsupials, with the dentition in the main of the Kangaroo, the hind-limbs were shorter and thicker, the fore-limbs longer and thicker; they were "gravigrade," not "saltigrade." Finally, the cranial and dental characters of the carnivorous Marsupial, of the size of the lion, were pointed out. To this extinct species, the name of *Thylacoleo carnifex* had been given. It was the destroyer of the gravigrade marsupial *Herbivora*, was able to cope with them, and the sole marsupial carnivore hitherto discovered in that relation, just as the *Thylacinus* makes a victim of the calf or sheep or great kangaroo of Tasmania at the present day. The placental Carnivora played an important part in the economy of nature, as Dr. Buckland remarked, being required to restrain the undue multiplication of the Herbivora.

The climate of Australia, and the extreme drought by which it is at times distinguished, and which has been known to extend over three years, was then touched upon, and the characteristic generative economy and structures of the extinct Marsupials were described as being well fitted, as exemplified in the Kangaroo, to allow of the young being carried for long distances in the pouch during the search after water by the parent at the thirstiest period

* A brief but interesting account of the Marsupials is given in "Old Bones," page 48; a little work by Rev. W. S. Symonds. London: R. Hardwicke, 192, Piccadilly, 1864.

of her existence, viz., when suckling her progeny. Now the Marsupial structures are associated with certain constant peculiarities in the structure of the skull; the jaws of the Australian Marsupials were similar to those of the opossum discovered by Cuvier in the Gypseous-beds of Montmartre, the pelvis of which was afterwards shown to have the characteristic small Marsupial bones in relation to the economy of the pouch.

The fossil mammalian remains from Australia were found both in caverns and in the Drift. The Drift was frequently of great depth, sometimes more than 100 feet, and in geological age might possibly extend backwards beyond the Tertiary period. At times of excessive flooding, a number of these fossil bones were laid bare by the washing away of their matrix, such seasons, of course, being taken advantage of for collecting them; this had notably been the case in Queensland. The remains of the younger Marsupials were mostly from the caverns, those of the older ones from the Drift. It is noteworthy that of the cavern remains, the skulls, all or nearly all, are cracked or gnawed as by the teeth of carnivora, and the inference naturally is that the younger Marsupials more often fell a prey to the predatory members of their own Order, whilst the older and stronger herbivores may have escaped. No remains of man have yet been found associated with these remains. Some of these larger forms of Marsupials were possibly co-existent with the first aborigines; man and his *dog* would naturally attack the largest first.

Sir Thomas Mitchell, the first Surveyor-General of Australia, discovered in the Wellington Valley caves thirty years ago a fragment of a lower jaw with a tooth: although of a size which suggested its relationship to a hippopotamus, it was determined to be marsupial and assigned to an extinct genus. Since that time teeth and bones have been found at various places over a region 1,000 miles across, and these have rendered possible the determination of the structure and habits of the animal, and finally the complete restoration of the *Diprotodon Australis.*

In the course of his address, Professor Owen remarked that "no chase of any living animal was half so exciting as the pursuit of an extinct one of which a passing glimpse had, as it were, been caught, and, of which, bit by bit, and year after year, one captures the elements for reconstructing the entire creature, of which a single tooth or a few bones had at first formed the sole basis upon which the entire fabric was eventually built."

VISIT TO THE BRITISH MUSEUM.

(The Fossil Fish Collection.)*

March 24th, 1877.

Directors—Henry Woodward, Esq., F.R.S., and William Davies, Esq., F.G.S.

The party having assembled in front of the Cases containing the fine collection of Fossil Fishes, Mr. Woodward called attention to the oldest fishes known, the Cephalaspidæ, represented by the genera *Scaphaspis*, *Cyathaspis*, *Pteraspis*, and *Cephalaspis*, and by *Pterichthys* and *Coccosteus* made famous by the writings of Hugh Miller. These early fishes are remarkable from the fact that although they possess well ossified head-shields, and in the case of *Pterichthys* and *Coccosteus* the tail has even the neural processes ossified, yet the notochord remains persistent as in the Lancelet (*Amphioxus*) and in the embryo of all modern fishes. In other words, the centra of the vertebræ are never consolidated. But although to a great degree destitute of a complete endo-skeleton, they were well defended by an exo-skeleton, consisting of hard dermal plates of bony enamel and by powerful spines. In some recent fishes, as the Sturgeon and Sharks, the bones are only partially calcified, and they are consequently termed cartilaginous fishes. In *Chelone*, too, amongst the Reptilia, the ribs and spinous processes are united to and help to form the carapace which serves as an exo-skeleton, and in the Crocodilia stout osseous dermal plates protect both the head and body. In the Sharks and Rays the shagreen is covered with compact or scattered ossified tubercles. After pointing out the fine series of Old Red Sandstone fishes, Mr. Woodward introduced to the Members his colleague Mr. William Davies, F.G.S., who has charge of the Fossil Fishes in the Museum.

Mr. Davies commenced his observations by drawing attention to the remains of the large Sauroid fishes, *Rhizodus* and *Megalichthys*, from the Carboniferous of Burdie House, as represented by their partially ossified bones and scales. These powerful preda-

* See Catalogue of Type Specimens of Fossil Fishes in the British Museum, by W. Davies, F.G.S., "Geological Magazine," Vol. viii. p. 208 and p. 334.

ceous fishes possessed teeth of two kinds—an outer row of closely set, short, conical fish teeth, and an inner series of widely separated, long, laniary, and highly enamelled teeth, which, in *Rhizodus*, range from three to six inches in length, and are so truly Saurian in character, that it was originally referred to the class Reptilia. The spinal column in *Rhizodus* was unossified, but the body was covered with circular bony scales, often of four or five inches in diameter. In *Megalichthys* the vertebræ are partially ossified, the centre remaining cartilaginous, thus forming a series of rings; the scales are rhomboidal and thickly coated with enamel, as are also the bony plates of the head. In *Saurichthys* the teeth, as in some Lizards, are implanted in a continuous groove, and the crown of the tooth is separated by a constriction from the fang.

The Dipnoi (double-breathers) are closely allied to the Ganoids, and are represented by *Dipterus* from the Old Red Sandstone, *Ctenodus* from the Carboniferous, and *Ceratodus* from Triassic and Oolitic deposits, their teeth being broad corrugated plates. Although the *Ceratodus* has living representatives in the rivers of Australia, no remains of the genus have been found in strata of later age than Oolitic.

The fishes of the Palæozoic rocks are all Heterocercal, the first Homocercal-tailed species being found in the Trias. From amongst the Oolitic species, Mr. Davies pointed out the fishes from the Solenhofen Limestone, which were the most perfectly preserved of all vertebrate remains, the complete outline, the bones, the fins, and the teeth, being all beautifully shown. The Lepidoids range from the Trias to the Chalk. The scales of this group are bony, covered by enamel, and are fitted to each other by a notch and a process which renders them mutually supporting. In this group also there is merely an unossified notochord. Their maximum development was in the Solenhofen Limestone and Wealden deposits. The teeth are conical or rounded, and, covering the roof of the mouth, were used for crushing. These fishes are found in the Lias of Whitby sometimes uncompressed.

Æchmodus and *Dapedius* are short, deep, laterally compressed fishes, peculiar to the Lias; the teeth in *Æchmodus* are pointed, in *Dapedius* they are bifurcated. The Pycnodonts have the mouth paved with flat, rounded or elongated teeth. In *Pycnodus* and *Gyrodus* the vomer supports five rows of teeth, the centre row in

Pycnodus being the largest, and the outer series the smallest; in *Gyrodus* the central and the two outer series are large, whilst the teeth of the intermediate rows are the smallest. Many of the species of this group are only known by their jaws.

Passing on to species from Cretaceous rocks, Mr. Davies reminded his hearers that Ctenoids and Cycloids begin in the Chalk, and that at the same horizon nearly all the genera and all the species of the older formations disappear. The Ctenoids have the free margins of the scales serrated, of which the perch is a good living representative, the fin-ray is not divided. The fine series of Chalk Fishes was then pointed out, and next those from Monte Bolca. Of Palæozoic forms, the Cestracionts have one representative now living, the *Cestracion Phillipi*, or Port Jackson shark of Australia. The *Psammodus* and *Cochliodus* (which latter had several teeth joined together) of the Carboniferous Limestone had the largest teeth, though no evidence of the form of the jaw has been left. Attention was then drawn to the teeth of *Acrodus*, from the Lias, to those of *Strophodus*, which, while assuming various forms, were all from one species, as the teeth of each row in the same mouth are dissimilar in form from those of any other row; and to the teeth of *Ptychodus*, which usually occur in groups of 50 or 60, while, except a few fin-rays, no part of the skeleton has been found.

A hearty vote of thanks to Mr. Davies, for his very instructive lecture, terminated the proceedings.

EXCURSION TO THE CRAG DISTRICT OF SUFFOLK.

APRIL 2ND AND 3RD, 1877.

Directors—WILLIAM WHITAKER, Esq., B.A., F.G.S., H.M. Geological Survey; J. ELLOR TAYLOR, Esq., Ph.D., F.G.S., F.L.S., Curator of the Ipswich Museum; and EDWARD CHARLESWORTH, Esq., F.G.S.

(*Report by* DR. J. ELLOR TAYLOR.)

A number of members of the Ipswich Scientific Society and of the Colchester Natural History Society having joined the party from London at Harwich, the entire body proceeded in small boats to cross the estuary to near the new pier at Felixstowe. Thence

they went by the new railway to near the newly-built station, after which they walked to the beach. Mr. Whitaker explained the marine denudations which are going on along the Norfolk and Suffolk coasts, and referred especially to the waste of the cliffs at Felixstowe. Afterwards Mr. Henry Miller, jun., the Honorary Secretary of the Ipswich Scientific Society, showed the waste which had occurred within the last twelve years, and produced coloured maps which showed the exact amount of waste and addition—the latter, perhaps, was worse than the former, inasmuch as it threatened Harwich harbour.

On reaching that part of the coast where the Felixstowe Cliffs begin to present their precipitous faces, just beyond the Bath Hotel, all the party were surprised at the splendidly clean sections which had been cut by the recent storms. At present there may be seen the effect produced by clear cut vertical slices—cut down some forty feet, in many places right down to the London Clay beds beneath. These sections expose the cross-current bedding of the Red Crag in a marvellously crisp and distinct manner, and as the spring sun shone on the richly coloured section it became almost artistic in its effect. Mr. Whitaker drew attention, first to the lines of cross or current bedding of the Crag, and said that this was a very characteristic feature of the Red Crag. He also adverted to the bays or indentations which may be seen here and there, and showed that when these hollows were seen a spring would invariably be found, the fact being that the water which had passed through the Crag beds could not permeate the London Clay, and so formed springs. In doing so, however, it carried away a good deal of lime dissolved out of the shells of the Crag, and so caused the Crag section to be hollow where the springs existed. Mr. Charlesworth described the more common species of these beds, and showed how the bivalve shells found with holes drilled through them had been killed by carnivorous Mollusca. He showed that the red whelk (*Fusus antiquus*) and the common dogwhelk (*Purpura lapillus*) lived together in the Crag seas, as they do in existing British seas. But, whereas a child could tell the difference between a *Fusus* and a *Purpura* now, in the ancient days of the Crag these two forms were so nearly alike that, although he had worked as a Crag geologist for nearly half a century, he often found it difficult to discriminate between a Crag *Purpura* and a Crag *Fusus*. The

same thing occurred with the genus *Trochus*. It was the easiest thing in the world for a conchologist to tell the difference between living British species; but it was exceedingly difficult to determine the Crag forms, owing to the way in which the latter ran into each other, so to speak. Mr. Charlesworth expressed his opinion that these were very strong facts for Darwin.

After a sufficient time for collecting had been allowed, the party proceeded past the Bath Hotel to the clay cliffs beyond Mr. Cobbold's house. These belong to the London Clay. Mr. Whitaker's remarks on the section here exposed were listened to with the interest they deserved. After pointing out how all the plants found fossilised in these beds were converted into iron pyrites, he showed the yellow band of pyrites which ran at even distances along the face of the cliff, along the lines of stratification. The broken and irregular way in which the direction of these bands occur, shows that the deposit has been subjected to "faults," and he also pointed out how the surface of the London Clay hereabout was hollowed, and that these hollows must have been eaten out before the Pliocene period, for most of them were filled in with Red Crag.

The party now made their way over the steep escarpment of the cliff, and across the fields beyond, to one of Messrs. Packard's "coprolite" workings. Dr. Taylor showed how these small coprolite nodules were originally deposited in the London Clay, that they could still be found there in the cliffs adjoining, where they were usually met with covered with iron pyrites, and that when the London Clay was denuded by weathering, the included phosphatic nodules would be weathered out and accumulate in seams, the iron pyrites decomposing into oxide of iron, and so furnishing the colouring matter for the Red Crag. The numerous angular and fantastically shaped nodules of flint, usually found at the base of the Red Crag, and often covered on their upper surfaces with barnacles, might have been carried from Norfolk when that county formed the chalky shores of the sea in which the Red Crag was formed, by means of coast or "foot" ice. The "box-stones," he considered, were the broken up and rolled fragments of a geological formation older than even the Coralline Crag, and possibly of Miocene age. About one in twenty of these sandstone nodules—which were so abundant that they were collected and bought and used for metalling the high roads near Felixstowe—contained casts of shells or, perhaps, fish teeth, or scutes or other remains of crocodiles,

whales, and even land animals, such as *Mastodon*. These "box-stones" were always found intermingled with the Chalk flints and phosphatic nodules at the base of the Crag. Sometimes slabs of sandstone were found, very little rounded. Underneath the city of Antwerp, across the German Ocean, the bed, of which these "box-stones" were here the rolled and broken up part, was to be seen in its natural and undisturbed condition. In reply to Mr. Charlesworth, who thought that the "box-stones" were of concretionary origin, Dr. Taylor said that could not be the case, as a microscopical examination of them showed the angular grains of sand cohering together.

A short stay was made on the way back to the new railway at a pit where Mr. H. Miller showed there were to be found large fragments and whole shells of *Cyprina Islandica*. By the kindness of Colonel Tomline and Messrs. Lucas, the entire party were conveyed to Ipswich along the Felixstowe Railway. After dining at the Lion Hotel, a visit was paid to the Ipswich Museum, where Dr. Taylor, the Curator, delivered a lecture on the new fossils of the "Canham Collection," recently presented to the Museum by Sir Richard Wallace, Bart., M.P., the newly-elected President.

Second Day.—All the visitors went by the 7.10 train on Tuesday morning to Wickham Market, which place was reached about eight o'clock. At nine o'clock the entire party proceeded in conveyances to Orford, by way of Tunstall Heath. At the further point of the heath the geologists proceeded on foot to Chillesford Brick-pit. At the brick-pit Mr. Whitaker explained the nature of the clayey deposit, and described its geographical extent. On leaving this pit and proceeding towards the high road another pit was reached, well known as the Chillesford Stack-yard Pit. Here Dr. Taylor described the Crag which was visible, and stated the shell-bed they saw was of much more recent formation than any of the other beds they had seen, and more recent than the well-known Norwich Crag. One feature, he said, about it was the larger number and proportion of Arctic shells it contained, *Mya truncata, Cardium Greenlandicum*, *Scalaria Greenlandica*, and others were adduced as evidence that this Chillesford Crag was the latest in deposition, and that its numerous Arctic fossil shells indicated the cold period which was then setting in—a period afterwards known as the Boulder Clay, or Glacial, Epoch, when the Northern Drift deposits of sand, gravel, and clay were accumulated.

Under Mr. Dalton's direction, were visited two pits opened in the Upper Red Crag, near the Butley Oyster Inn. Many species were here obtained, and Dr. Taylor said these pits were well-known to fossil conchologists for the number of *fresh water* shells they yielded —a fact so novel that when fresh-water shells were found in the Norwich Crag it was termed by the late Sir Charles Lyell, the "Fluvio Marine Crag." Dr. Taylor thought that the present physical conditions of the Baltic Sea represented the ancient condition of the later period of the Red Crag more accurately than anything else he was acquainted with. In the Baltic, owing to the large amount of melted ice, the conditions were partly brackish: and fresh-water shells might be found living side by side with marine shells.

The Coralline Crag, in its two stages of "Upper Bryozoan Crag" and "Lower Shell Crag," was next to be visited. The party accordingly were driven three-quarters of a mile beyond Sudbourne Church. Here they stopped at a Crag pit, where Mr. Whitaker showed there was an overlap of the Red Crag above the true Coralline Crag, or rather the upper portion of the latter. The Red Crag was bleached by the percolation of water through its loose mass, which had carried down the red oxide to the lower beds, and actually stained the latter to a different colour than that in which they are usually found. After leaving this pit, three or four hours were passed in examining various other excavations in the Coralline Crag. The most notable was that to be seen near Sudbourne Park gates. In this pit the geologists found a large number of characteristic fossil Polyzoa such as *Alveolaria*, *Cellepora*, *Fascicularia*, *Hornera*, &c.

The pits in Sudbourne Park are well-known for the great number of fossil shells they yield. These shells occur in a lower stratum of the Coralline Crag than that so almost entirely made up of Polyzoa that it has derived the name of "Coralline Crag" from it. Near Sudbourne Hall is a pit showing the outcrop of this stratum, and here many specimens of such characteristic shells as *Cardita senilis*, *C. scalaris*, *Cyprina rustica*, *Astarte Omalli*, *A. bipartita*, &c., were obtained.

Another outcrop of this Lower Coralline Crag shell-bed was seen at the "Keeper's Pit," after which the entire party made their way to a sumptuous luncheon provided for them by Sir Richard

Wallace in the Keep of Orford Castle. Mr. W. Whitaker presided, the Mayor of Ipswich filling the vice-chair. After luncheon the Chairman gave "The Queen," following which he proposed the toast of the day, "Sir Richard Wallace." The Mayor of Ipswich seconded the vote of thanks, and referred to the splendid collection of fossils which had been presented to the Ipswich Museum by Sir Richard Wallace, which would soon be completely arranged, and would form one of the most valuable features of the institution. Dr. Foulerton proposed a hearty vote of thanks to the Directors of the day, Mr. Whitaker, Dr. Taylor, and Mr. Charlesworth. The carriages having been ordered, the party returned to Wickham Market in time to catch the evening train to Ipswich, Colchester, and London.

ORDINARY MEETING, April 6th, 1877.

William Carruthers, Esq., F.R.S., Vice-President, in the Chair.

The following Donations were announced :—

"Abstracts of the Proceedings of the Geological Society," Nos. 332 and 333; from the Society.

"Journal of the Quekett Microscopical Club," No. 33; from the Club.

"Proceedings of the West London Scientific Association," Vol. i., Part 4; from the Association.

"Journal of the Society of Arts," March, 1877; from the Society.

"Transactions of the Watford Natural History Society," Vol. i., Part 6; from the Society.

"Proceedings of the Warwickshire Naturalists and Archæologists' Field Club," 1876; from the Club.

"Proceedings of the South Wales Institute of Engineers," Vol. x., Nos. 2 and 3; from the Institute.

"Proceedings of the Natural History Society of Glasgow," Vol. iii., Part 1; from the Society.

"Note Préliminaire sur le Terrain Silurien de l'ouest de la Bretagne," by Dr. Charles Barrois; from the Author.

"Note sur le Terrain Dévonien de la rade de Brest," by Dr. Charles Barrois; from the Author.

"The Lias of Fenny Compton, Warwickshire," by Thomas Beesley, F.G.S.; from the Author.

"On a Further Extension of the Rhætics . . . . . ." by the Rev. P. B. Brodie, M.A., F.G.S.; from the Author.

"On the Effect of Chlorine in Colouring the Flame of Burning Bodies;" "On the Borders of the Fossiliferous and so-called Primitive Formation;" "On the so-called Primitive Formation of the South Coast of Norway;" "On the Chemical Composition of some Chilian Minerals;" "On Evansite, a New Mineral Species;" "On Phosphorite from Spain;" "On the Geological Epochs at which Gold has made its appearance in the Crust of the Earth;" "On the Alleged Hydrothermal Origin of certain Granites and Metamorphic Rocks;" "On the Chemistry of the Primeval Earth;" "On Some Points in Chemical Geology," Nos. 1, 2 and 3; "Researches in British Mineralogy," Nos. 1, 2 and 3; "Dr. T. Sterry Hunt's Geological Chemistry;" "On Dr. Sterry Hunt's Geological Chemistry;" "Chemical Examination of the Oriental Jargon;" "On the Aymara Indians of Bolivia and Peru;" "The Structure of Rock Masses;" "On the Contraction of Igneous Rocks in Cooling;" "On Volcanos;" "On the Geology of Donegal;" "On Meteorites;" "The First Chapter of the Geological Record;" "Quarterly Reports on the Progress of the Iron and Steel Industries in Foreign Countries," No. 2, 1871, to No. 1, 1876. All by David Forbes, F.R.S.; from the President, Professor Morris, F.G.S.

"What Is, and What Is Not, the Cause of Activity in Earthquakes and Volcanos," by R. A. Peacock, C.E., F.G.S.; from the Author.

"The Geology of the Eastern End of Essex (Walton-Naze and Harwich)," by William Whitaker, B.A., F.G.S.; from the Author.

The following were elected Members of the Association:—

James Day, Esq.; Henry Tryon, Esq.; William Walker, Esq., F.G.S.

The following Papers were read:—

1. On Certain Genera of Living Fishes, and their Fossil Affinities.

By Miss Agnes Crane.

(Abstract).

After expressing acknowledgments to Dr. Günther, F.R.S., and Mr. W. Davies, F.G.S., of the British Museum, for information afforded, the Author observed that although the zoological limits of the lowest group of Vertebrates were apparently easily defined, the Fishes nevertheless prove to be most curiously linked to the Invertebrata below and the Amphibian Reptiles above. The position which the lowest vertebrate form (*Amphioxus lanceolatus*) should occupy in the animal kingdom has been much debated, Agassiz separating it from all other fishes, Hæckel placing it in a distinct division of the Vertebrata, and Professor Semper removing it from the vertebrates altogether. Professors Owen and Huxley, however, retain it among the fishes. In this species, which is notochordal throughout life, there is no enlargement of the skull for the reception of the brain; the skin is scaleless, lubricous, and transparent; and the eyes are not more highly developed than in the common leech. The Lancelet is without heart, swim-bladder, ribs, and even rudimentary limbs. Its mode of respiration differs from that of all other fishes—a fact commented on by Prof. Goodsir, who compared the enlarged phrangeal sac of *Amphioxus* to that of the tunicated mollusks, or sea-squirts; he also considered the species to be allied to the Annulosa; and M. Kowalev'sky has more recently traced a close affinity between it and the early stages of some Ascidians. Thus in *Amphioxus* are combined characters shared by the Annelida and Tunicata.

If the Lancelet reveals unexpected relations between the Vertebrata and the Invertebrata, the *Lepidosiren*—the highest of all the fishes which is capable of living either in the water or out of it—displays an admixture of piscine and amphibian characters which is no less remarkable. This extraordinary genus, which is placed by Prof. Owen in a provisional Order between the reptiles and fishes, forms the highest Order of Prof. Huxley's classification of fish, namely, the *Dipnoi*, or "double breathers." Only two

species are known—*Lepidosiren paradoxa,* first described by Dr. Natterer as inhabiting the swamps in the vicinity of the River Amazon in South America, and *Lepidosiren annéctens*, subsequently discovered on the African continent. In these singular animals, popularly known as "mud fishes," well-developed reptilian lungs are co-existent with functional internal branchæ—a structure peculiarly adapted to their mode of life. Three parts of their existence is spent on the flooded river tracts, and the remainder hybernating in mud-cocoons in the dried up swamps from which the waters have entirely receded. The body of the *Lepidosiren* is fish-like, and covered with small cycloid scales, simply constructed pectoral and ventral fins are present with a dorso-caudal fin. As the notochord is persistent, the skull partly bony, partly cartilaginous, while the costal and neural arches are well ossified, it forms a link between the bony and cartilaginous types of fishes. The dentition consists of a pair of vomerine teeth and two molars in each jaw. The heart is three-chambered, and true lungs exist with rudimentary external branchæ, and functional internal ones. The mud fish is carnivorous, and takes its food in a somewhat unusual manner, subjecting it to a thrice-repeated process of mastication before finally swallowing it.

In 1870, another living dipnoid inhabiting the fresh and brackish waters of the Queensland rivers, was referred by Mr. Krefft to the genus *Ceratodus*, and the subsequent investigations of Dr. Günther and Prof. Huxley have confirmed the accuracy of his determination; although the genus had been hitherto known only by the fossil teeth of numerous species occurring abundantly in Triassic and occasionally in Oolitic strata, in Britain, Germany, and India. These fish bear much external resemblance to the *Lepidosiren*, while the similarity of internal structure, with but slight modifications of the dental apparatus, and, above all, the co-existence of a lung with gills, prove the close affinity existing between the *Ceratodus* and the Mud-fish; and although the former approach *less* to the amphibian type than the latter, they must obviously be placed side by side in any natural system of classification. The teeth of the Australian *Ceratodus* much resemble those of the fossil Ceratodonts, and these again are closely related to those of *Ctenodus*—a genus widely distributed in Carboniferous strata—and also to those of the Devonian genus *Dipterus*. The living dipnoids of Australia, Africa, and South America are, therefore,

found to be the survivors of a well-defined and characteristic group of fishes first appearing in the Devonian age, and represented in Carboniferous, Triassic, and Oolitic strata. The link is then lost sight of, until their lineal descendants re-appear widely distributed on the surface of the present world ; a further illustration of the fact that species which have the greatest vertical range in time have also the widest geographical distribution, a wide distribution proving the antiquity of the genus.

After referring to the significance of the fact that the group of living fish most closely allied to the amphibian reptiles should be represented in the Devonian rocks, long before the most simply constructed amphibians appeared on the scene of life in the swamps of the Carboniferous period, the author proceeded to discuss the classification of the Dipnoi. The families Protopterinæ, Ceratodontinæ, Ctenododipteridæ and possibly Phaneropleuridæ are included in the Order by Dr. Günther, who proposes to unite the Dipnoids with the Ganoids, considering them to be closely related, more especially to the Sub-Order Crossopterygidæ; but Prof. Huxley, while admitting their affinity, prefers to retain them in a separate Order, as he is of opinion that they possess many important differences.

The researches of Dr. Newberry in America appear to indicate that the Dipnoi had also some affinities with the group of fishes known as Placoderms, for the dentition of the genus *Dinichthys*, a gigantic Placoderm occurring in the Huron Shales of the Upper Devonian series, is on the same plan as that of the *Lepidosiren*, although it is about a hundred times larger. The jaws of this "terrible fish" were each two feet long, the length of the body was from fifteen to eighteen feet, and its diameter three. The posterior portion was encased in huge ventral and dorsal shields resembling in shape and structure those of the genus *Coccosteus* rendered classic by the pen of Hugh Miller. The ponderously armed *Placoderms* had a comparatively short range in time, appearing only in the Upper Silurian and Devonian rocks; it is, therefore, possible that being unable to cope with the lighter armed and dominating race of active ganoids, they died out, leaving no immediate descendants. The group is considered by Prof. Huxley to form a link between the Ganoids and the living plated Siluroid Teleosts of the African rivers (*Clarias*, *Loricaria*, etc.).

In considering the range and distribution of the various piscine

families in time, we find that authenticated remains of Sharks, Placoderms, and Cephalaspids have been obtained from the Lower Ludlow Beds of the Upper Silurian rocks in Europe, but in America no fossil fishes have as yet been discovered before the Devonian epoch, when the remains of numerous genera occur abundantly, differing, however, from the European forms—a dissimilarity probably owing to the different physical conditions existing in the two areas at the time of the deposition of the series. In the Old Red Sandstone of Scotland and Russia fresh-water species predominate, while in the marine limestones of Devonshire and the Eifel the fossils indicate a shallow marine deposit; but the greater part of the American Devonian was apparently laid down in an open sea, and thus a monster marine fauna flourished, not so generally represented in Europe. In both worlds, however, the Ganoids far exceeded the Elasmobranchiate fishes in number.

The following Table (page 119) shows the distribution of the various Orders and Sub-Orders in geological time, according to the classification of Prof. Huxley, but commencing with the highest forms.

It will be observed that no traces of the Pharyngobranchii have been detected in the "records of the rocks," but the soft and perishable structure of the Lancelet, the only living representative of the Order, causes the non-representation of this lowest form of ichthyic life to be less remarkable. Of the cartilaginous Marsipobranchii, the horny teeth alone would be susceptible of preservation, and their absence has been commented on as negativing the evidence of progressive development among fishes, as the simplest forms should obviously appear first on the scene of life in order to give place to their more highly organised descendants. The "Conodonts" from the Lower Silurian rocks of Russia, figured by Pander, in 1856, as the teeth of small sharks, have not been accepted as of true piscine origin. Prof. Owen retains only three species as possibly the teeth of fishes, and is of opinion that the remainder might be "either the ornaments of crustaceans or the spines, hooklets, or denticles of naked mollusks or annelides." Great numbers of these "cone" teeth were subsequently detected in Carboniferous strata in England and America, and it is suggested that they may be the teeth of cyclostomous fishes like the Hags and Lampreys, and thus represent the Marsipobranchii in the ancient Silurian seas.

Orders & Sub-Orders.	Formations.											Generic Fossil Types.	Generic Living Examples.
	Palæozoic.					Mesozoic.				Cainozoic			
	L. S.	U. S.	D.	C.	P.	T.	L.	O.	C.	T.	R.		
6. DIPNOI			?	?	?	?		?			×	*Dipterus? Ctenodus? Ceratodus?*	*Ceratodus, Lepidosiren.*
5. TELEOSTEI									×	×	×	*Beryx, Osmerus*	Herring, Carp, Perch.
Placodermi[7]		×	×									*Dinichthys, Coccosteus, Pterichthys, Asterolepis.*	
4. GANOIDEI— SUB-ORDERS.													
a. Amiadæ										?	×		*Amia calva*, the dog-fish of the American lakes.
b Lepidosteidæ[8]			?	?	×	×	×	×	×	×	×	*Lepidotus, Palæoniscus**	*Lepidosteus*, Bony Pike of America.
c. Crossopterygidæ[9]			×	×	×	×	×	×	×		×	*Osteolepis, Glyptolepis, Macropoma.*	*Polypterus, Calamoichthys* of Africa.
d. Chondrosteidæ			?				×			×	×	*Chondrosteus*	Sturgeon (*Accipenser*).
e. Cephalaspidæ[10]		×	×									*Auchenaspis, Cephalaspis.*	
f. Pycnodontidæ[11]				×	×	×	×	×	×	×		*Platysomus, Pycnodus, Cœlodus.*	
g. Acanthodidæ[12]		×	×									*Acanthodes.*	
3. ELASMOBRANCHII—													
Squalidæ		×	×	×	×	×	×	×	×	×	×	*Acrodus, Ptychodus*	Sharks, Dog-fishes, *Cestracion Phillippi.*
Raiidæ								×	×	×	×	*Rhinobates*	Torpedo, Skates, etc.
Chimæridæ[13]			?					×	×	×	×	*Edaphodon, Elasmodus*	*Chimæra monstrosa*,† *Callorhynchus.*
2. MARSIPOBRANCHII											×		Hag (*Myxine*), Lamprey (*Petromyzon*).
1. PHARYNGOBRANCHII											×		Lancelet (*Amphioxus*).

* According to Dr. Traquair, there is no true *Palæoniscus* in the British Carboniferous rocks. † King of the herrings.

1. Gullet-breathing. 2. Pouched-gills. 3. Thinly-plated gills. 4. Glistening scaled. 5. Perfect boned. 6. Double-breathing 7. Buckler-headed. 8. Bony-scaled. 9. Fringe-finned. 10. Buckler-headed. 11. Thick-toothed. 12. Large-spined. 13. Monster-headed.

Among the Elasmobranchiate fishes the Sharks have ranged from the Upper Silurian epoch to the present day, and one genus seems to have varied but slightly, the Port Jackson shark of Australia being a descendant of the early Cestracionts—a once numerous family, now verging towards extinction. The Ganoids, so numerous in Palæozoic times, are represented in the existing fauna by seven or eight genera, and but one of these, the Sturgeon, the least characteristic of the group, is found in European waters.* Two of the remaining forms, all dwellers in fresh water, occur in Africa, and four are found in the rivers and lakes of North America, where their preservation is probably owing to the fact that some portions of that continent, truly the old world of geologists, have never been submerged since their upheaval from the first Silurian seas.

It is through the Crossopterygidæ, or "fringe-finned" Ganoids, that Prof. Huxley considers the passage from the fishes to the reptiles took place. All the families of this Sub-Order are characterised by the possession of lobate paired fins, with a central scaly axis or stem surrounded by a fringe of fin rays, and traces of this structure are observable in the fins of the dipnoal *Ceratodus* and *Lepidosiren.* The Saurodipterini, Glyptodipterini, and Phaneropleurini are restricted to the Palæozoic rocks; the latter bear much resemblance to *Lepidosiren.* In some genera of the Cœlacanths, which range from the Carboniferous to the Chalk, the walls of the air-bladder are ossified. The Polypterini, comprising the *Polypterus* and *Calamoichthys* of Africa, are the only survivors of this once prevailing Order at the present day. The genus *Polypterus* is remarkable by the possession of a double-cellular air-bladder nearly approximating to the true lungs of the Dipnoi.

In conclusion, it was observed that we have evidence in the life history of fishes of the extinction of some groups after a brief existence, while others endure through untold ages. The few living ganoids are undoubtedly the surviving descendants of a numerous and powerful race prevailing in the Devonian epoch, and the discovery of fossil dipnoal forms, the ancestors of *Ceratodus* and *Lepidosiren*, proves the antiquity of the Dipnoi. The existing Teleostean fauna, on the contrary, is found to be of comparatively modern date. Moreover, in considering the fact that the

* A species of *Polyodon*, allied to the Sturgeons, inhabits the rivers of Northern China.

early fishes are remarkable from a combination of diverse characteristics, which subsequently become the distinguishing peculiarities of distinct Families and of a higher Order, we have further evidence that the ancient Ganoids formed the parent stock from which the succeeding fishes, amphibians, and reptiles have diverged. In some sauroid Devonian fishes the position and structure of the teeth foreshadow those of the Labyrinthodont reptiles; in others, the throat is protected by gular plates—a fashion retained in the Carboniferous Amphibia. Again, in some species the scales are surface pitted, like the scutes of Crocodiles. While in the notochordal weak-limbed amphibians of the Coal Measures, with minute body scales, and partly osseous skulls, we cannot fail to recognise structural peculiarities now found in the swamp-dwelling mud-fishes. Thus in the anomalous "scaled sirens" we have the persistent type of an ancient group of fishes in which now, as in the old time, the piscine and amphibian characters are so united as to completely efface the line of demarcation between the Orders, and effectually link the Fishes to the Reptiles.

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2. On Ellipsoidal Nodules of Ironstone.

By Lieut.-Col. J. D. Shakespeare, F.G.S., Assoc.Inst.C.E.

(Abstract.)

The specimens now exhibited consist of an ellipsoid of ironstone, 18in. × 16in. and 9in. in thickness, and pieces broken from similar nodules. The spiral formation of the large specimen, which seems to have about two-and-a-half coils in its construction, is so remarkable that, when it and others were first seen by the author at a little distance they were thought by him to be old ship's fenders, so greatly did they resemble short lengths of thick rope tightly coiled. In the fractured specimen is a crystal of quartz as large as the Koh-i-noor and almost as bright, and small crystals of nickel, sulphur, lime, iron, &c. These ellipsoids lie in the shale composing the roof of most coal-seams in the Aberdare District; those exhibited were from the six-feet vein of the Rhondha Valley. Sometimes their lower surface is in actual contact with the coal beneath, but generally they are several inches, and occasionally feet, above it, according to the nature of the coal-seams, but they are never found as if sunk into the coal. Wherever they

are found, they are in layers parallel with the strata, and invariably have the major axis in its direction. Where they are of small size they are not numerous, but when large they frequently lie so close together as to form a continuous course. They are never found in roofs of rock or hard shale, but in the softer shale called "Blue Metal."

It is remarkable that coal fossils are rarely ever amongst these ellipsoids, though fossil ferns and *Sigillaria* are sometimes found a few feet from them, but, as a rule, where the one is plentiful the other is scarce; they are always found above the coal and never below it.

These "Ball Mine," as they are locally called in South Wales, do not exist in every seam of that coal-field, but I believe they are in greater quantities and larger in that district than elsewhere. The proportion is about 5 tons to every 400 tons of coal; from twenty to fifty weigh a ton. Similar nodules are found in some seams in Yorkshire and Lancashire, where they are known by the name of "Doggers" and "Bullions;" occasionally, too, they are met with in North Wales; in fact, they are characteristic of certain seams in certain districts. They are not in every coal district, nor when they are found in one seam of a district does it follow that they are in another of the same district; and they are more numerous in connection with steam than with house coal.

In conclusion, the author thought the occurrence of these ferruginous bodies deserved careful attention, and he promised to give all the information he could obtain on the subject.

VISIT TO THE BRITISH MUSEUM.

(South African Reptilian Remains.)

April 14th, 1877.

Director—Professor Owen, C.B., LL.D., F.R.S., &c.

(*Report by* Dr. J. Foulerton, F.G.S.)

Professor Owen having met the party in the North Gallery, led the Members to the cases containing the Reptilian Remains from South Africa, which the learned Director then described.

During the Liassic, the Triassic, and, perhaps, also the Permian periods, lakes or estuaries, much larger than the lakes at present known in Central Africa, occupied a tract of the southern portion

of that continent, extending northwards from N. Lat. 35°, and eastwards from E. long. 19.45°. In the mud and sand deposited by these waters were buried the remains of the plants and animals which occupied the adjacent land-surfaces, and amongst others those of the Reptilia, to which I now wish to draw your attention. The thickness of these lacustrine and estuarine deposits, represented now by shales and sandstones, injected with trappean and other igneous rocks, exceed 11,000 feet. They have been elevated into a high table-land, traversed by mountain ranges, the chief of which, singularly enough, has received the name of "Drachenberg." At the localities richest in the remains before us, the original mud has been converted into a quartzose sandstone of extreme hardness. The first examples of these fossils were discovered by Mr. A. Geddes Bain, in blasting the rocks for a military road in 1838; others have been annually transmitted to the present time. The highest grade of organisation determinable in these fossils is reptilian; no tooth or other trace of mammalian life has been detected. But they revealed an interesting and unexpected fact, viz., that many of the Reptilian remains presented certain characteristics now only found in Mammalia, and particularly in the order Carnivora; thus, the large upper canine teeth of this huge carnivorous reptile (exhibiting the skull of the *Lycosaurus tigrinus*) resembled those of the extinct sabre-toothed *Machairodus*, in their proportions as well as shape, even to the finely serrated edge; the canines descending outside the lower jaw, like those of the walrus and musk-deer. The humerus, also, of this carnivorous reptile presents the foramen or canal for the passage of a nerve or vessel above the internal condyle, as in the Feline carnivora. Yet the bones and sutures of the skull, its shape and the small size of the brain cavity, prove the remains exhibited to be those of a reptile.

With these lethal canines are associated incisors and molars of the ferine type, and more distinct in their several kinds than had hitherto been observed in the Reptilian class; such reptiles, of which several generic and specific modifications were shown, had, therefore, been grouped in a distinct Order termed Theriodontia.

When there were such carnivorous reptiles, armed with formidable canine teeth, we might be sure that there were correspondingly large herbivorous animals of some kind for them to prey

upon. Accordingly were next shown the remains of large herbivorous reptiles, known to be such by the nature of their crushing and grinding teeth, and by the impressions on the bones of the skull and processes for the attachment of the large muscles which move the jaw backwards and forwards. Of these reptiles examples of the genera *Tapinocephalus*, *Pareiasaurus* and *Anthodon* were exhibited. They are *Dinosaurian*, but of an earlier or lower type than our European Mesozoic kinds. The vertebræ were only partially ossified, and in *Anthodon* were biconcave, resembling, in this particular, the vertebræ of fishes. A tube filled with gelatinous matter had passed through the vertebral bodies of *Pareiasaurus*, with flatter articular surfaces: forming a continuous moniliform canal, from before backwards, originally filled by the remains of the embryonic structure called the notochord. Some of these reptiles had only two large canine teeth in the upper jaw, thence called *Dicynodont*, and had no teeth at all in the lower. Of this order were shown specimens of a singular genus (*Ptychognathus*), whose triangular skull, marked with prominent ridges, had almost a crystalline outline. These Dicynodonts had large temporal muscles, showing that they were carnivorous. Others of these reptiles had no teeth at all in the adult state, and were accordingly called Oudenodonts. From the trenchant margins of the jaws they were probably carnivorous, like the snapping turtles of America.

But one of the strangest of these fossil reptilian skulls was of the genus *Endothiodon*, in which the palate, like that of some fishes, and also as in the extinct reptilian *Placodus*, of European Trias, was armed with crushing palatal teeth. The lower jaw also had corresponding teeth, though not so many as the upper. A small skull from the Koonap deposits, with two condyles for articulation with the vertebral column, showing it to have been an Amphibian or Batrachian, was finally demonstrated as claiming by its characters to be a member of the Labyrinthodont family.

In other parts of the world—in Germany, in Russia, in Nova Scotia, and in Central India—reptilian remains have been found in some respects similar to those obtained from South Africa. These palæontological facts, added to others derived from the distribution of some recent species, suggested, the Professor finally remarked, other geographical features of the globe than now characterise its surface, and the Indian Dicynodonts indicate that

there might once have been direct land communication between South Africa and India of which Madagascar, the Mauritius, and other islands of the Indian Ocean, are now the only remains.

EXCURSION TO GRAYS, ESSEX.

APRIL 21ST, 1877.

The weather was so extremely unfavourable that only a small number of Members assembled at Fenchurch Street Station, and the idea of abandoning the excursion was entertained, but, encouraged by Mr. M. Hawkins Johnson, the party took train, when the weather became comparatively fine. On arrival at Grays, Mr. Johnson led the way to the great Chalk pit, where he pointed out the peculiar junction of the Upper Chalk with the overlying later deposits, marked, as it is at this place, by deep indentations or "pipes" filled partly with Lower Tertiary and partly with Pleistocene sands.

The well-known brick-pit, which has yielded so many mammalian remains, and the sections in which expose so well the Post-Pleiocene beds of the Lower Thames Basin, was then visited. Notwithstanding a diligent search, a portion of a tibia, probably of *Bos primigenius* was the only mammalian fossil found, though remains of *Elephas* are sometimes by no means uncommon. The usual genera of Mollusca, *Cyrena, Unio, Valvata* and *Bithynia* were, however, easily obtained.

Notices of the Geology and Palæontology of Grays have already appeared in these pages. See Reports of Excursions to Grays, Vol. ii. p. 29, and p. 245, and Vol. iv., p. 123.

ORDINARY MEETING, May 4th, 1877.

Professor John Morris, F.G.S., President, in the Chair.

The following Donations were announced:—

"Abstracts of the Proceedings of the Geological Society," Nos. 334-335; from the Society.

"Journal of the Society of Arts," April, 1877; from the Society.

"Transactions of the Manchester Geological Society," Vol. xiv., Part 8; from the Society.

"Annual Report of the Smithsonian Institution for 1875;" from the Institution.

"Geology of Northamptonshire," &c., by W. J. Harrison, F.G.S.; from the Author.

"The Hertfordshire Ordnance Bench Marks," by John Hopkinson, F.L.S., F.G.S.; from the Author.

"The Grotto Geyser of the Yellowstone National Park" (U.S.A.); from Dr. F. V. Hayden.

The following were elected Members of the Association:—

William Mason Cole, Esq.; William Bancroft Espeut, Esq.; Thomas Floyd, Esq., F.G.S.; John Edward Marshall Hall, Esq.; Miss A. Maria Horsnaill; Francis M. Jennings, Esq., M.R.I.A., F.G.S.; J. Love, Esq., F.R.A.S., F.G.S.; Frederick Short, Esq.

The following Papers were read:—

1. On the Geology of Leicestershire.

By William J. Harrison, Esq., F.G.S., Curator of the Town Museum, Leicester.

The rocks of Leicestershire are more varied in age, character, and composition than those of any of the adjoining counties. Probably no district could be chosen which would better illustrate the effects of geological structure upon the life and occupations of its inhabitants.

If we take a brief general survey of the county, we shall find the rock-masses fall into five broad divisions (see Sections, page 135):—

I. In the north-west rises the hilly, almost mountainous, region of Charnwood Forest, composed of igneous and metamorphic rocks.

II. Besides eight isolated masses of Carboniferous Limestone, we find the Coal Measures extending westwards of Charnwood, beyond the boundary of the county, into Derbyshire. Fragments of Permian pebble-beds rest upon the Coal Measures in small and scattered patches.

III. "Red Rocks" of Triassic age, form much of the land north, east, south, and south-west of the Forest region, covering in fact all the western half of the county not occupied by the rocks already mentioned.

IV. In the eastern half of the county stiff bluish clays of Liassic age preponderate with a hard bed of Marlstone; whilst above them, in the extreme north-east, and in a few outlying masses, sands and limestone of Oolitic age are found.

V. Lastly, scattered in varying thickness, and with great irregularity over all the rocks already mentioned, there are beds of clay, gravel, sand, and pebbles, which we call Drift, relics of the last Glacial Period and submergence beneath the sea. The alluvial deposits of our rivers—still in course of formation—bring our geological history down to the present day.

Let us now consider each of these great rock divisions a little more in detail.

I. The Crystalline and Slaty Rocks of Charnwood Forest.—These have long been regarded as a geological puzzle. No fossil remains have ever been found in them which we might have compared with those found in rocks elsewhere. In structure they resemble both the Cambrian rocks of Wales and the Silurian beds of the Lake District; whilst it is not impossible that they may be older than either, and belong to the Laurentian system. In appearance and composition they present a remarkable variety, and the question of their origin has not been less debated than that of their age. Extending from Blackbrook on the N.W. to Bradgate on the S.E., a distance of about seven miles, a line can be traced, dividing the slates, &c., which can be seen to dip to the N.E., from those which dip S.W. This anticlinal line was first noted by Sedgwick in 1833. East of it we get coarse gritty slates, ashy in appearance, at Moorley Hill, Nanpantan, &c., with intrusive masses of syenite at New Cliff and Buck Hill. At

Whittle Hill the rock is so fine-grained and siliceous as to pass into a quartzite. This is very much jointed, breaking up readily into prismatic masses. It is quarried for hones, which are known throughout England as the "Charley Forest" oilstones. Passing over Beacon Hill, where the slates attain a height of 840 feet, we notice in some little quarries near Woodhouse Eaves some markings on the bedding planes which have been considered of organic origin. At Swithland and Groby there are some extensive slate quarries. At the former place the principal pit is nearly 200 feet deep. The beds here dip nearly due east, at from 30 to 40 degrees. On the eroded edges of the slates, the Triassic Red Marls are seen to rest, the bedding following to some extent the inequalities of the ancient surface. The Midland Railway Hotel, at St. Pancras Station, is roofed on one side with Swithland, and on the other with Groby slates. They have also been used in the steps round the Albert Memorial in Hyde Park.

Mountsorrel is an outlying mass of syenite, passing into a hornblendic granite by the presence of a small quantity of mica. There are very extensive quarries here, and the stone is much used for kerbs and paving-setts. Between Swithland and Mountsorrel we have a very interesting exposure in Basil or Brazil Wood of a curious kind of gneiss. It is within a few feet of a syenite boss, and just outside the wood a mass of diorite is to be seen. It is intended to excavate at this point, so as to lay bare the junction of the three rocks. On the west of the anticlinal line, there are some large quarries in the syenite knolls of Groby, Markfield, and Cliff Hill. Bardon Hill rises to a height of 902 feet (the highest point in Leicestershire), but the rock here, as shown in the very large quarries, is a kind of felstone. From this point by Peldar Tor, to High Cademan and High Sharpley, we get a most interesting region, most of which appears to be composed of beds of volcanic ashes and agglomerates. Nearly in the centre of the elevated and craggy surface of this tract stands the Monastery of St. Bernard. To the north-east (but still west of the anticlinal) we find a limited area of compact, hard, pale-coloured quartzites. It is difficult to match these with any rocks east of the central axis, and it seems probable that a fault runs along the anticlinal, with an upthrow to the west. If this be the case, these quartzites (which are exposed near the Old Reservoir, &c.) are about the oldest beds of the Charnwood region.

We can trace a southerly extension of the Charnwood axis in the bosses of fine-grained syenite, which are worked in South Leicestershire at Enderby, Croft, Stoney Stanton, Narborough, and Sapcote.

The comparative proximity of Charnwood Forest to London, and to the east and south-east of England generally, ought to ensure the rapid development of its excellent syenite, granite, and slate quarries; and with improved means of communication, the future will, doubtless, see a great development of the special industries of this district.

II. THE LEICESTERSHIRE COAL-FIELD.—When the seams of coal with their accompanying strata were first deposited, they doubtless stretched continuously all over the region of Charnwood Forest, and were connected with the Nottingham Coal-field. Since the upheaval of the Forest district, all the Coal Measures which once covered it have been swept clean away—denuded off—together with a vast thickness of the syenites and slates themselves, until now not a patch of coal is left on that area.

The lowest beds of the great Carboniferous System are those of the *Carboniferous Limestones* which are found cropping out at intervals to the north-west of Charnwood, at Grace Dieu, Osgathorpe, Barrow, Breedon Cloud, and Breedon. This limestone is very impure, containing much carbonate of magnesia; it is in fact a "dolomite," and is largely quarried for lime burning. It also occurs at Dimminsdale, where it contains ores of lead, copper, iron, zinc, &c., but in small quantities only. Several fossil shells occur, mostly as casts, *Productus* and *Bellerophon* being the most common. The limestones are overlaid by beds of shale, which are well seen in the quarries at Grace Dieu. They are about fifty feet thick in this district, and are capped by the *Millstone Grit*—a very hard, coarse sandstone, which is only exposed in one or two small patches near Thringston, &c.

The Coal Measures.—About 2,500 feet of sandstones, clays, shales, and coal-seams overlie in this district the Millstone Grit. Of these, however, the lower half may be regarded as unproductive, the coal-seams contained in it being too thin to admit of profitable working. The Coal-seams of the upper part, too, do not spread in uninterrupted sheets at regular depths. The same great upheaval which acted chiefly under Charnwood Forest also dislocated and disturbed all the surrounding country, elevating

portions here and there above the rest, and so breaking the continuity of the Coal-seams and producing what are called "faults." The surface inequalities so produced have since been worn down to a tolerably level surface, so that we only know of the existence of these "faults," when in following a coal-seam we find it suddenly stop short, abutting on a rock of quite different character. The chief "faults" run from N.W. to S.E. parallel to the anticlinal axis of Charnwood Forest. They are named (1) the Coleorton, or Boundary Fault, which stretches from Ticknall to Bardon Hill; (2) from this the Heath End Fault seems to branch out, whilst further to the S.W., the Boothorpe Fault and the Moira or Main Fault run nearly parallel to it. A number of minor faults run nearly at right angles to these.

The effect of unequal upheaval was to elevate the district between the Heath End and Boothorpe faults, *i.e.*, all the part to the N.W. and S.E. of Ashby-de-la-Zouch. From this part thus exposed to denudation, the coal-beds were speedily pared off, and we thus have the lower unproductive measures standing like a wall between the western coal-producing districts of Moira and the eastern or Coleorton division. We may therefore suppose that the chief seams of coal of these two latter districts are identical, and were once continuous; and from the general similarity in character, number, and order of succession of the beds in each, this seems a fair conclusion.

In the Moira district the main-coal is $14\frac{1}{2}$ feet in thickness, but it is not of equal quality throughout, and is not all extracted. In the Coleorton district it is about six feet thick. The boundary of the Moira district by Stanton, Gresley, Donisthorpe, Measham, Willesley, and Woodville is pretty clear, the coal-seams cropping out on all sides; but the Coleorton district extends southwards and eastwards beneath the New Red Marl to an unknown distance. At Whitwick Colliery a bed of dolerite was struck at a depth of 155 feet. This is a true volcanic rock, and was probably ejected from a vent somewhere in the great fault at the foot of Bardon Hill. It was 60 feet thick, and had turned the bed of coal on which it rested to cinders. Still further to the south, coal has been reached at Ibstock, Nailstone, and Bagworth; whilst recently similar beds have been proved further east at Desford, but this is probably close to the eastern boundary. About six miles south of Desford, at Elmesthorpe, a boring of 1,500 feet

in depth found unproductive coal-measures dipping nearly vertically. But westwards, between the Nuneaton and Ashby coal-fields, the ground is as yet untried, and would seem to present fair probabilities of success.

The Permian.—In a few spots to the south and west of the Ashby Coal-field, as at Measham, Packington, &c., there occur beds of pebbles embedded in a paste of red marl. These are almost certainly of Permian age, and as the pebbles they contain can be traced back to the Carboniferous and Silurian rocks of the West of England, whilst they are angular and some even striated, they probably afford a proof of the recurrence of glacial periods at various geological epochs.

III. The New Red Sandstone, or Trias.—The lowest division of the "Red Rocks" is the *Bunter (variegated) Sandstone.* Pebbly beds of this age occupy the district about Netherseal and Donisthorpe. In Leicestershire, as elsewhere, there is considerable difficulty in separating the Triassic and Permian beds, from want of good sections, and the absence of fossil evidence. Both are unconformable to the Carboniferous rocks, and also to one another. Above the Bunter Conglomerates come the *Keuper Beds.* The lowest member is a thick sandstone, called the "*Waterstones,*" from its everywhere affording an abundant supply of water when pierced by wells sunk through the Red Marl above.

The Red Marl with Upper Keuper Sandstone constitutes the greater part of Leicestershire west of the River Soar, and usually extends a mile or so east of that river. The town of Leicester is built on the uppermost beds of this division. It contains a bed of sandstone seen at Orton-on-the-Hill, Diseworth, and especially at the Dane Hills close to the west side of Leicester. Here, in a cutting of the Leicester and Burton Railway, a fine section is seen, showing the characteristic "false bedding" (produced by the action of currents) in perfection. A little crustacean, *Estheria minuta*, is found in these beds, with teeth and spines of *Hybodus.* A massive nodular band of gypsum occurs towards the top of the Red Marl. It is well seen in the cutting of the Midland Railway's Main Line near Thurmaston. It is in the Red Marl of Shropshire, Cheshire, and elsewhere, that thick beds of rock-salt occur. Indeed, the whole Triassic system seems to have been deposited in inland seas, saturated with salt. In Leicestershire we have

traces of this in the numerous casts of salt crystals which cover the surface of the light-coloured marls in many places. Ripple-marks, sun-cracks, and rain-pittings afford further signs of the condition of things at that period. The red colour of the marls is due to the presence of oxide of iron, and it is generally found where this is abundant that traces of life are few.

IV.—The Lias and Oolites of East Leicestershire.—*The Rhætic Beds.*—Resting on the top of about 1,000 feet of Red Marl and Sandstone, there occur certain thin bands of Grey Marls, Black Shales, and Nodular Limestones, whose fossil contents are of the highest interest. The only clear sections of them at present known in this county are to be seen in certain brick-pits at the northern extremity of the Spinney Hills, a low range forming the eastern boundary of the town of Leicester and of the Soar Valley. These I was fortunate enough to discover in 1873. The top of the Keuper Red Marl is there visible, and above it is a thick bed of Grey Marl, which in turn is surmounted by the famous Bone-Bed, a layer some three inches thick, composed of remains of *Ichthyosaurus*, *Plesiosaurus*, *Labyrinthodon*, with numerous fish remains, as *Hybodus*, *Ceratodus*, *Nemacanthus*, &c., with numerous other interesting fossils. Next come about 9ft. of black and light-coloured shales, containing the characteristic shells, *Avicula contorta*, and *Cardium Rhæticum*, and the whole is capped by bands of hard nodular limestone. It is still a matter of dispute whether these beds belong to the Trias or to the Lias. Probably they are true "passage beds," having in the lower part Triassic, and in the upper Liassic affinities. In these beds I found a new species of star-fish, since named *Ophiolepis Damesii*, and a fish—*Pholidophorus Mottiana.* The outcrop of the Rhætic Beds can be followed northwards by Barrow-on-Soar and Elton to Newark.

The Lias.—The *Lower Lias* beds have long been worked at Barrow-on-Soar, and more recently at Kilby Bridge. They consist of alternations of dark shales with valuable hydraulic limestones, surmounted by a great thickness of shales. At Barrow the lowest limestone bands are nodular, and contain *Ostrea liassica* in great numbers. Above them we find the Fish, Insect, and Saurian Beds. *Ammonites planorbis* is met with in the shales, and *A. angulatus* a few feet above it; but another form which I have been in the habit of calling *A. catenatus*, appears to

be new, and will be described by Dr. Wright in his forthcoming "Monograph on Ammonites" (Palæontographical Society). At Kilby we get rather higher beds. Here *Ammonites Bucklandi* and *A. Conybeari*, with *Gryphea incurva* and *Rhynchonella variabilis* occur in great numbers.

The total thickness of the Lower Lias Beds is about 600 feet, for a boring for coal near Billesdon Coplow reached that depth entirely in this formation; had it been persevered with a little further, it would doubtless have entered the Red Marl. The district occupied by the stiff bluish clays of this division is mostly in the condition of pasture land, and forms the chief portion of the great hunting and stock-rearing district of East Leicestershire. The tunnels on the Nottingham and Melton Railway now in course of construction have lately afforded some good sections of the upper part of these beds. They contain *Hippopodium*, *Cardinia*, and *Pleurotomaria* in abundance.

The Marlstone or Middle Lias.—The "Rock-bed" is a limestone containing much iron. Exposed to the air it weathers brown, and constitutes excellent corn land. In the north-east, at Wartnaby and Holwell, it is about 25ft. thick, but decreases to about one foot between Keythorpe and Hallaton. Its outline is very irregular, as it sends out bold spurs to the west, as at Burrow Hill and Billesdon, and, indeed, forms an escarpment along its whole extent. At its junction with the clay beds beneath numerous springs issue. A good example is in the picturesque little ravine of Holwell Mouth, where the River Smite issues from the base of the Rock-bed in this manner.

The Upper Lias Shales are rarely seen, being covered over with Drift. The "Fish and Insect Beds" are to be seen in some pits near Keythorpe.

THE OOLITES.—Resting upon the Upper Lias Shales is a stratum called the *Northampton Sand* from its development further south, where it is extensively worked for ironstone. In Leicestershire it only occurs in detached patches or outliers, although no doubt it was once continuous over the whole district. Robin-a-Tiptoes, a hill about some 750ft. high, and about 11 miles east of Leicester, is capped by hard calcareous beds of Northampton Sand, as are the adjacent eminences of Whadborough Hill, Barrow Hill, &c. Near Neville Holt it is about 20ft. thick. Ironworks were commenced here, but have been discontinued.

The Lincolnshire Limestone.—The labours of Mr. J. W. Judd have made it clear that this important bed belongs to the *Inferior* Oolite, thus being older than the Great or Bath Oolite, with which it was formerly considered contemporaneous.

The main line of outcrop just enters the county on the N.E., near Crown Point, and near Croxton Kyrial. From the latter point it extends westwards to Sproxton, sending, what is probably a long spur, down nearly to Waltham and Stonesby. Here there are several quarries, and fossils are abundant, but occur mostly as casts. In South-east Leicestershire we also get an interesting outlier of the Lincolnshire Limestone on the top of Neville Holt Hill.

V.—Post-Tertiary Deposits.—There are many interesting exposures of *Mid-Glacial* or *Pre-Glacial Beds.* These are usually sandy, composed of detritus derived from the neighbouring rocks only, and are seen to be overlaid by true Boulder Clay. They contain a few derived fossils, and much carbonaceous matter, which admirably indicates the false-bedding. Good sections are seen in the brickyards at Rotherby, Melton Mowbray, Billesdon, Broughton Astley, and at Ayleston, Leicester Abbey, &c.

Boulder Clay.—The usual appearance of the Boulder Clay in Leicestershire is as a stiff bluish clay, often weathering brown where exposed. It is full of quartz pebbles, &c. Attempts have been made to divide the *Drift* in Leicestershire into three portions. The gravelly beds containing flints and Chalk fossils have been distinguished as *Eastern Drift*, the constituent rock-fragments appearing to have principally come from that direction. The Boulder Clay proper, with large transported masses of Millstone Grit and Carboniferous Limestone, is entitled *Northern Drift*, while, lastly, Charnwood Forest seems itself to have acted as a centre of distribution of boulders, which constitute the *Forest Drift.* No hard and sharp line of demarcation can be drawn between the Eastern and the Northern Drift, although the former appears to be the older of the two. In the present state of our knowledge of the Glacial Deposits, it is, however, useful to retain these names as expressing general facts.

Pre-historic Man.—Although I have very carefully searched the river-gravels, I have as yet obtained none of the roughly chipped flint instruments assigned to the *Palæolithic* age. As bones of the

FIG. 1.—WEST LEICESTERSHIRE. GENERAL SECTION.

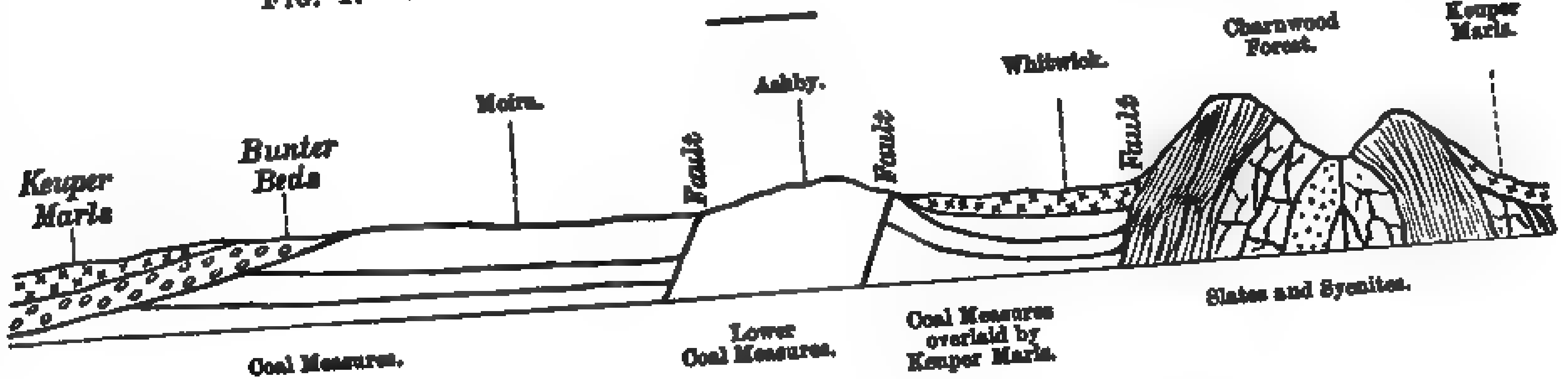
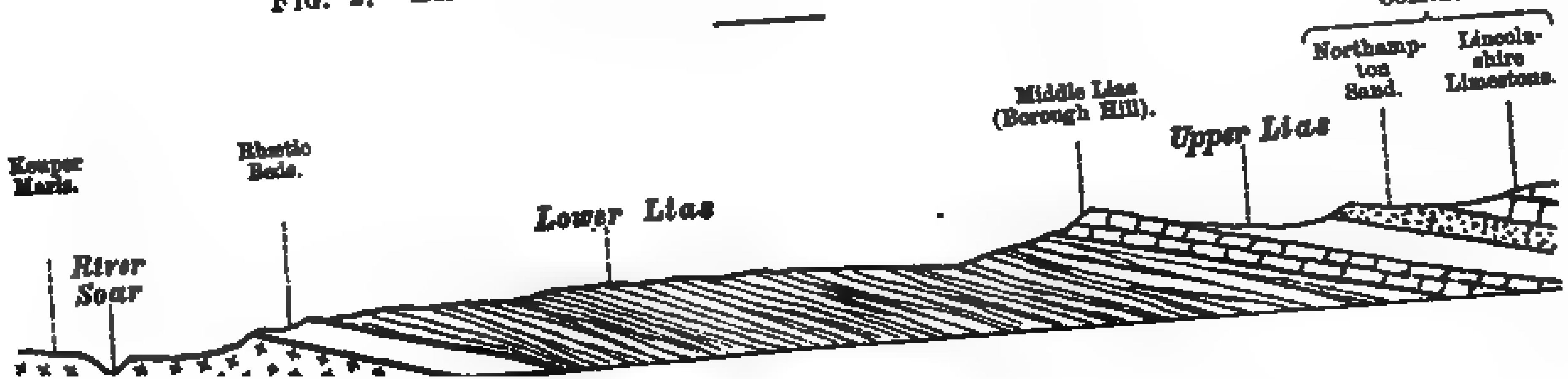


FIG. 2.—EAST LEICESTERSHIRE. GENERAL SECTION.



Mammoth, Rhinoceros, &c., however, occur rather plentifully, it seems possible that by continued research we may identify the presence of man at the same period.

The later or *Neolithic* stone implements are not rare. Many celts, hammer-heads, scrapers, &c., have been found. When the use of stone tools had been superseded by others of metal, the former tools were still used in religious ceremonies, political observances, household rites, &c., in which it has been the custom of all nations to preserve, as far as possible unchanged, the outward signs and tokens of such usages. In this way it can readily be imagined that these curious stone objects would gradually come to be regarded as sacred, and this alone is a proof of their great antiquity. Thus, in the British Museum there are two beautiful Etruscan gold necklaces, each of which has, as a pendant, a small flint arrow-head. In the Leicester Museum there is a "Lucky-stone" from Wymeswold, which was the centre of a similar superstition. It is an oval flint pebble with a hole passing through it, and had been preserved in one family for many generations. It was reputed to keep off witches, prevent the entrance of fairies into the dairy, charm off warts, keep milk from going sour, with various other valuable virtues. But such a belief was at one time not uncommon, and the children's song—

> "Lucky-stone, lucky-stone, bring me some luck,
> To-day or to-morrow, by twelve o'clock,"

is another remnant of a wide-spread superstition, whose origin may date further back than is generally supposed.

2. On the Distribution of Flint in the Chalk of Yorkshire.

By J. R. Mortimer, Esq.

EXCURSION TO WANTAGE.

MONDAY, MAY 7TH, 1877.

Directors—Professor JOHN MORRIS, F.G.S., President Geologists' Association, and E. C. DAVEY, Esq., F.G.S.

(*Report by* E. C. DAVEY, Esq., and W. H. HUDLESTON, Esq., M.A.)

This was an excursion, to a certain extent, supplementary to the Faringdon Excursion of the previous year (Proc. Geol. Assoc., Vol. iv., p. 543). Mr. Davey, who had on that occasion acted as the chief local Director, was desirous to complete the history of the "Sponge Gravel" district, by exhibiting to the Members the unrivalled collection from those beds, which is stored in his private museum at Wantage. As Mr. Davey has thoroughly studied and re-classified the numerous Sponges on a far more scientific basis than has been done previously, it was all the more necessary for those Members interested in Cretaceous Palæontology to have the opportunity of inspecting so complete a collection, and of hearing Mr. Davey's views on the subject.

After delivering a short address explanatory of the Cretaceous geology of the neighbourhood, Mr. Davey conducted the visitors to his museum, in which were displayed a fine series of the fossils of the district, together with collections of coins, pottery, celts, and the spolia of a Roman villa recently discovered near Wantage, an account of which was read before the Archæological Institute in February. The fossils are all catalogued in a pamphlet printed expressly for the Members of the Association, two copies of which have been presented to the Library.

Were we to judge solely by the results recorded by the Geological Survey, we might conclude that Wantage was an unpromising district for the palæontologist, inasmuch as the scantiest lists of fossils belonging to the Upper Greensand and Chalks are to be found in the Memoirs to Sheets 13 and 34; but Mr. Davey's catalogue is the best proof that no part of the Chalk range from Wilts to Herts possesses more characteristic fossils than Berks, and no part of Berks so complete as Wantage.

After partaking of the generous hospitality of Mr. Davey *al fresco*, the party proceeded in conveyances to Lockinge Clump, East Hendred, and Cuckhamsley hill. The lowest Cretaceous beds seen on the route are "whitish calcareo-siliceous strata," known as Firestone,

resting on the Gault and forming a prominent narrow ridge, which overlooks and bounds the Vale of White Horse for many miles in succession. It is the same stone that is quarried near Godstone Merstham, and Nurstead, in Surrey, and has been extensively used in the Isle of Wight for building churches, &c. (Mantell, "Geological Excursions," Chap. viii., p. 177). It may probably be correlated with the Blackdown-beds and with Dr. Barrois' zone of *Ammonites inflatus*. No fossils had hitherto been reported from this zone in Berks, but Mr. Davey has obtained more than a dozen species, the most remarkable being some Echinoderms of the genus *Cardiaster*. The most abundant one is a flat species with 5 ambulacra—a specimen of which may be seen in York Museum labelled *Micraster Murchisoniæ*. Besides these urchins, the Firestone contains *Pecten orbicularis*, *Pholadomya decussata*, *Plicatula inflata*, and three species of *Nautilus*.

Resting on this Firestone are beds, thirty feet in thickness, of soft glauconitic sands well exhibited in various sections round Wantage, and seen by the Association on Lockinge Clump. These sands are decidedly fossiliferous, especially in their higher portion, and yield *Pecten asper*, *Discoidea subuculus*, *Pleurotomaria Rhodani*, *Terebratula biplicata*, and other species characteristic of the Warminster-beds with which the Wantage sands seem identical (see Quart. Journ. Geol. Soc. for 1875, p. 272, and Barrois' "Recherches sur le Terrain Crétacé Supérieur de l'Angleterre et de l'Irlande," pp. 86, 62, 70).

After passing through East Hendred, the Members lingered somewhat in a quarry of Lower Chalk (zone of *Holaster subglobosus*) half way up Cuckhamsley hill. This hill has other attractions besides fossils, for on its summit is a large mound, which Kemble supposed to be the most commanding barrow in England, and the resting place of Cwichelm, the first Christian king of Wessex ("Archæological Journal" for 1857, p. 131). Arrived on the summit of the downs, the party was addressed by Professor Morris on the physiography of the immense district which is commanded by this elevated ridge. All the points in connection with last year's excursion to Faringdon were in view, and the Professor completed his exposition of the structure of the country, as given in the Report, to which reference has already been made.

After exhausting the geological side of the subject, the history of the district came in for its share of attention, and the Members were much interested in a brisk discussion which ensued between

Mr. Davey and Mr. James Parker as to the origin of the name of the mound which is on the summit of this part of the Wantage downs. As this question belongs to the domain of archæology rather than of geology, no further reference need be made to the subject here. But it might be gathered from what was said that the boundary between Wessex and Mercia in these parts seems to have run along the line of the Chalk escarpment. Hence, like all border districts, many a battle would be fought within its confines between those two rival combinations of the Anglo-Saxon tribes, who had but lately wrested the fairest portions of this island from the Romanised Britons.

A general move was now made to a fine section in the nodular "Chalk Rock," 500 yards west of Cuckhamsley Barrow, and here hammers and chisels were eagerly brought into requisition, with results which evidently gave both surprise and satisfaction. At the date of the Geological Survey, the Chalk Rock of Berks was returned as well nigh barren, but subsequent researches have proved that this singular bed is as fossiliferous in Berks as in Herts. The more this bed is studied, the more striking are its peculiarities. The Chalk Rock may be seven and possibly ten to twelve feet in thickness, but nine-tenths of the fossils are found in a seam that rarely exceeds three or four inches in depth. Above this thin line fossils are scarce and restricted to half-a-dozen kinds; below, the rocks are devoid of any but minute organisms. Above, the Chalk is milk-white, soft, and interspersed with flints; but the "Chalk Rock" is hard, cream-coloured, filled with dark phosphatic nodules, and contains no flints. Above, not a single gasteropod has yet been discovered;* but the moment the Chalk Rock is reached, an extraordinary assemblage of univalves is disclosed. Deep-sea bivalves are present, but the majority of the fossils belong to the genera *Trochus*, *Cinulia*, *Pleurotomaria*, &c., and as these are all inhabitants of shallow waters, we must conclude that a beach existed where these molluscan remains are embedded. Nevertheless, the Chalk Rock contains no trace of sand, or pebbles, or wood, to denote the vicinity of land. The conditions under which the Chalk Marl was deposited seem to have been repeated in the Chalk Rock—both being "littoral" and not "abysmal" deposits—for we find *Hamites*, *Scaphites*, and gasteropods in both. Of the Echinoderms, the most abundant

* According to Professor Phillips, Gasteropods are unknown in any part of the Yorkshire Chalk.—"Rivers, Mountains," &c., Chap. vii., p. 182.

and characteristic is a dwarf species, which is probably that distinguished as *Cardiaster pygmæus* of Forbes, by Mr. Price in his communication to the Geological Society, March 7, 1877. From these remarks it will be gathered that the Chalk Rock is a stratum of peculiar interest, and worth the attention of palæontologists. Numerous quarries are worked in this rock near the summit of the Berkshire Downs from Ilsley to Uffington, and afford excellent opportunities for further investigations and discoveries.

The visitors would willingly have spent more time in extracting the beautiful and well-preserved fossils which were revealed at almost every stroke of the hammer, but it was found necessary to commence the journey homewards, and this was accomplished by a pleasant drive along the ancient grassy road known as the Ridgeway and downwards through the grounds of Betterton House and Lockinge Park. Wantage was reached at half-past five, which allowed a little time for tea and refreshments. Then the party travelled to Wantage Road Station by the novel conveyance of a steam tramway, and left for their various destinations by the last up-train, having thoroughly enjoyed their visit to Wantage and the Berkshire Downs, under the favouring conditions of a hearty reception, a charming drive, successful fossil hunting, and brilliant weather.

VISIT TO THE MUSEUM OF THE ROYAL COLLEGE OF SURGEONS.

(Red Crag Mammalian Remains.)

May 12th, 1877.

Director—Professor W. H. Flower, F.R.S., F.G.S., &c., Conservator of the Museum.

(*Report by* Prof. G. S. Boulger, F.L.S., F.G.S.)

The Members having assembled in the Palæontological Hall of the Museum, Professor Flower directed their attention to the Mammalian Remains from the Red Crag, and illustrating his remarks by the specimens before him, proceeded to observe that these remains were obtained from the so-called coprolite-beds which occur at the base of the Crag, resting on the London Clay, between the rivers Orwell and Deben, and which are worked for the manufacture of super-phosphates. The remains found in these beds consist chiefly of shark's teeth, the shells, etc., of inverte-

brates and bones. They are derived from older rocks, being rolled, water-worn, and often pholas-bored. The commonest fossils are the teeth and some of the very hard parts of the skeleton of Cetaceans. They are derived mostly from the Miocene; some, however, from the Eocene and some from beds of Pliocene age; but on the whole they may be said to be late Miocene or early Pliocene. Taking the Orders of the Mammalia in descending order, we find the Insectivora and Rodents almost absent, but one species of beaver has been discovered by Professor Ray Lankester. The Carnivora are more numerous; among them are the teeth of hyæna, of a small leopard, and of bear, and the curious tuberculated tooth of *Hyænarctos*. Of this genus a right and a left first upper molar were obtained at Waldringfield, and show no appreciable difference from those of the original species from the Sivalik Hills. Dr. Falconer's generally received name is misleading, as the animal has no near affinities to *Hyæna*, but is a generalised type of bear. It has been found in the Pliocene of Montpellier, in the South of France, and in Spain, but the genus was new to England. The Walrus (*Trichecus*), is remarkable for its enormous upper canines, the other teeth being reduced. It feeds on molluscs and crabs. A closely allied genus (*Trichecodon*) is represented in these beds by its tusk alone. A lower jaw found at Antwerp, and named *Alactherium*, perhaps belongs to the same animal. The Ungulata are represented by the teeth of deer, pigs, horse and *Hipparion*—a more generalised type of horse, with the splint-bones replaced by rudimentary side-toes, which is found also in the Miocene beds of Pikermi, in Greece. The teeth of *Hipparion* may be readily distinguished from those of horse, by an island-like circular apex of a rod of enamel, which in the tooth of horse is connected with the other ridges like a peninsula. The Tapir (*Tapirus priscus*), also occurs. The Proboscidea are represented by *Mastodon arvernensis*. In this group a gradual transition can be traced in the teeth from *Dinotherium*, through *Mastodon* and *Stegodon* to *Loxodon* and *Elephas*, marked by the elongation and narrowing of the ridges of enamel and the core of dentine, and the further development of the cement. The Sirenia are a most interesting group, represented by a very few widely distributed forms. They differ from the Cetacea in being herbivorous. The *Dugong* is found from the Red Sea to Australia; various species of the *Manatee* off the Atlantic coasts of America and Africa; and the *Rhytina*, which was exterminated in the last century only, on Behring's Island, in the North Pacific.

The extinct genus, *Halitherium*, which has been found in the Miocene of Darmstadt, France and Italy, and recently in the Crag, links the *Dugong* and the *Manatee*, and looks, in fact, like the ancestral form of all the Sirenia. The remains of Cetacea are very abundant in the Crag, the most perfect series being that of the Brussels Museum. One of the commonest fossils is that known as the ear-bone—the auditory bulla of the tympanic bone. This bone is completely anchylosed in adult man and most mammals, but only loosely so in the Cetacea. It is denser and harder than any ivory. The whales are divided into two very distinct classes the whalebone whales and the toothed whales. All these ear-bones belong to the former class. The ziphoid whales, now rare, were abundant in the Crag. The upper jaw is toothless, forming the characteristic hard, bony snout. The genus *Squalodon* is only represented by a few teeth. Though allied to the grampus, it was more generalised in structure than any existing cetacean.

EXCURSION TO LEICESTERSHIRE.

WHIT-MONDAY, MAY 21ST, 1877, AND FOLLOWING DAY.

Directors—WILLIAM J. HARRISON, ESQ., F.G.S. (Curator of the Town Museum, Leicester), REV. T. G. BONNEY, M.A., F.G.S., and REV. E. HILL, M.A., F.G.S.

(*Report by* MR. WM. J. HARRISON, F.G.S.)

FIRST DAY.—THE LIAS AND OOLITES OF EAST LEICESTERSHIRE.

The London detachment left St. Pancras by the 8.30 a.m. train, arriving at Market Harborough at 10.48 a.m. Here the party at once proceeded to examine the sections exposed in the brick-yards close to the station. Here the junction of the Lower and Middle Lias is exposed, showing—

1. Soil	2 to 3 ft.	
2. Upper Lias Clay, with *Ammonites communis*, and *Belemnites compressus*	3 ft.	
3. Brownish band of ironstone . . .		9 in.
4. Soft irony sandy bed, containing great numbers of *Ammonites serpentinus*, *A. bifrons*, *A. Holandrei*, and *Belemnites compressus* .	2 ft.	

5. Bluish Clays	9 ft.	
6. The Marlstone Rock-bed, a micaceous ferruginous sandstone, with *Ammonites margaritatus*, *Belemnites paxillosus*, *Cardium truncatum*, and *Avicula novemcostæ*		15 in.
7. Clay	3 ft.	
8. Band of "Skerry," with ironstone nodules, containing specular iron, and *Avicula cygnipes*		6 in.
9. Brown Clay	3 ft.	
10. Bluish Clays	8 ft.	
11. "Skerry"	1 ft.	
12. Clay	3 ft.	

Most of the above-named fossils were obtained by the party, who then entered carriages which were in waiting, and proceeded eastwards, along the valley of the River Welland to Medbourne, a village situated in a valley between the two Oolitic outliers of Slawston Hill and Neville Holt. Dismounting at the foot of the latter eminence, the party passed along the cutting in course of construction for the Midland Railway's new line from Melton Mowbray to Medbourne. It was the great object of the day's work to examine the fine sections exhibited along the line, and we may at once state that every facility was afforded for this purpose by the kindness of the engineers in charge, and Messrs. Logan and Hemingway, the contractors. The cutting at the west foot of Neville Holt Hill displayed an admirable and fresh section of a fault, running E. and W., and throwing down the beds on the north some 10 or 12 feet, so as to bring the blue clays and *Serpentinus* beds of the Upper Lias on a level with the Marlstone Rock-bed on the south. At the south end of the cutting the Fish and Insect limestones of the Upper Lias were noted, with the Paper-shales above them. *Ammonites annulatus* was very numerous here.

In consequence of the wet state of the ground, the party ascended the hill directly from the western side, instead of walking round to the south. Passing over a long slope of Upper Lias clay, the junction with the Northampton Sand was found to be marked by numerous springs. This latter bed, also known as the Lower Estuarine Series, forms here the very base of the Inferior Oolite. It is finely shown in the ironstone quarries on the southern brow of the hill, which were largely worked for a short time, furnaces being

also erected close to. The ore was not, however, found sufficiently rich to pay, and the quarries were closed in 1875. The Northampton Sand is here about 20 ft. thick. The upper portion is brown, friable, and marked by dark-brown bands, often concentric, which are very rich in iron. Lower down it passes into a hard ferruginous sandstone, the blocks being usually blue-hearted. Several fine specimens of *Terebratula sub-maxillata* were found here, with *Rhynchonella cynocephala*, an *Ostrea*, and *Pecten lens*. Fragments of wood are common, and in patches of whitish sands many plant markings were visible. Returning from this point, the party passed along a narrow cutting, in which, and in the neighbouring allotments, thin fissile limestones were seen, representing the Collyweston Slate. On the very top of Neville Holt, quarries were examined in the Lincolnshire Oolite Limestone, not very fossiliferous here, but full of corals.

From the hill-top a splendid view of the surrounding district was obtained, and Mr. Harrison pointed out that the outlying Oolitic strata which constitute the hill, had been preserved by a fault running east and west along the northern foot, throwing down the beds to the south. To the south and east the view extended over the valley of the Welland to the main outcrop of the Inferior Oolites, which form there a low, yet well-marked range of hills, the northern termination of which is known as the "Cliffe" of Lincolnshire. Northwards and westwards are devious valleys formed by streams cutting through the Marlstone Rock-bed of the Middle Lias. Descending the hill, the carriages were quickly reached, and after refreshing at the "Neville Arms," a start was made northwards, following very nearly the new line of railway. In this way the gradual thickening of the "Rock-bed" was well observed, as the route lay nearly in accordance with its strike.

Time compelled the omission of the Slawston cutting, and passing through Hallaton, the next halt was made at the village of East Norton. A tunnel was being driven through the hills S.E. of the village, the Rock-bed being the floor. In the open cutting north of the tunnel, the Upper Lias Clays were finely exposed for 50 or 60 feet in depth. The portion here seen consists of dark-blue pyritous clays, weathering to a light colour when exposed to the atmosphere, and then containing much selenite, with bands and concentric balls of hydrated peroxide of iron, formed by the decomposition of nodules of iron pyrites. The same beds had been seen by the party, *en passant*, in the brickyard at Moor Hill Lodge, just

before entering East Norton. These unfossiliferous beds rest, in Leicestershire, upon clays full of *Ammonites communis*, and are surmounted by clays with layers of septaria containing *Leda ovum.* At this point the Drift was well seen, overlying the clays. It contained many well-striated boulders, chiefly of Carboniferous Limestone and Millstone Grit, with great numbers of the common Liassic fossil, *Gryphea incurva.* Passing northwards through Lodington, several of the railway bridges in course of construction were examined, the material being the Marlstone Rock-bed. The stone was of a greenish-blue tint, and contained innumerable quantities of two brachiopods, *Terebratula punctata* and *Rhynchonella tetrahedra. Belemnites paxillosus,* and *B. clavatus* were also abundant. These fossils usually contained in their interior a mass of crystallized carbonate of lime, and they formed a natural decoration to the stonework.

On reaching Robin-a-Tiptoes Hill (755ft. high), it was found that time did not permit of the ascent being made. This very characteristic flat-topped hill stands on a plateau of Marlstone, the long slope is formed of Upper Lias Clay, and it is capped by Northampton Sand. Whadborough Hill to the north, and Barrow Hill on the east, are similar outliers. The conspicuous conical hill due west is named Colborough, and has a well-wooded summit. Dense woods in this neighbourhood usually mark thick deposits of Boulder Clay, such land being difficult to bring under cultivation. On the west side of Robin-a-Tiptoes a deep railway cutting was examined, which afforded a magnificent section of the Marlstone Rock-bed, here nearly 20 feet thick. It was interesting to note the passage downwards from friable brownish sandstone (due to weathering influences) to blue-hearted masses, and finally beds of dense blue ferruginous sandstone. The iron in the latter exists in the state of carbonate, but under the influence of air and water it becomes changed into the peroxide, which is of a brownish hue. Several good fossils were obtained in this cutting, including *Pecten æquivalvis, P. dentatus, P. liasianus, Pentacrinus lævis,* &c., besides the common ones already mentioned. A large fragment of wood, apparently of a coniferous tree, was also examined with interest.

After partaking of tea in the village of Tilton, a westerly course was taken past Billesdon Coplow—a rounded hummocky mass, which is an outlier of Marlstone, and is celebrated in hunting story—through the village of Billesdon to Leicester. The Bell

Hotel, in Humberstone Gate, had been selected as head-quarters, and here the party found an excellent dinner awaiting them, to which indeed they were prepared to do full justice, as it was nearly 8 p.m., and the day's work had been long and arduous. We have however, omitted to mention one object seen during the day, which, though not strictly geological, attracted much attention. In several of the railway cuttings through the Liassic clays, the party were, enabled to witness the work of the new steam excavating machine, to which the navvies have given the euphonious appellation of "American devil!" It consists of a powerful steam-engine running on lines laid on the bottom of the cutting, and with rails on each side of it for the passage of trucks. In front is a large crane carrying by chains an immense steel bucket, provided with prongs in front, and a movable bottom. This is let down, and then dragged up the whole face of the cutting by the steam-engine, the contents being then dropped into a truck. In excavating soft strata this machine must prove of great utility, doing the work of fifty men.

In the evening it had been intended to examine the Collection in the Town Museum, where Mr. Harrison had also intended to exhibit, by the aid of the oxyhydrogen lantern, a series of views illustrative of the scenery, rocks, and fossils of Leicestershire, but owing to the late arrival of the party this also had to be omitted.

SECOND DAY.—CHARNWOOD FOREST, THE MONASTERY, AND MOUNTSORREL.

Starting in carriages at 9.30 a.m., the party, which was reinforced by several members of the Burton-on-Trent Natural History Society, drove first to the syenite quarries at Groby. Here the Keuper Marl is seen to dip away on all sides (quaquaversal dip), from the central boss of syenite, which must have formed an island, or shoal, in the Triassic sea. At a point about a mile further on, in Steward's Hay Wood, the Rev. Mr. Bonney and the Rev. E. Hill pointed out an interesting junction of the slates and syenites, clearly proving the latter to be intrusive. Passing the syenite knoll of Markfield, the interesting rocks known as the "Altar Stones" were examined, after which luncheon was partaken of at the Forest Rock Hotel. Not much speech-making was done, but votes of thanks to the Directors, and to the Secretary, Dr. Foulerton, were proposed, carried, and duly responded to.

After luncheon the most interesting region of altered rock, which extends from Green Hill past Peldar Tor, was closely examined. The Rev. E. Hill had served out to each Member an outline map, on which the character, dip, &c., of the rocks in the neighbourhood of Peldar Tor were laid down. The whole ridge appears to be composed of volcanic agglomerates and ashes of varying fineness, having a felspathic base, in which crystals of felspar, often with worn edges, and blebs of quartz are visible. The felspar crystals may possibly have been ejected from volcanic vents in their present state, but the quartz appears to be of subsequent formation. Many of the Members went over the Monastery of St. Bernard, which is situated in the midst of this wild and rocky region, and which belongs to the Cistercian Order. It was built in 1835, from designs furnished by the elder Pugin.

Crossing the anticlinal valley, and leaving Whittle Hill on the left, the road was taken which circles round the north side of Beacon Hill. From this point a ridge stretches to the village of Woodhouse Eaves, along which the party proceeded to walk, while the carriages went round to meet them in the village. A rather awkward brook here intersected the line of route, giving rise to some good "water-jumping." The rocks of the ridge (known as the Hanging Stones of Woodhouse Eaves) were found to be indurated slates, agglomerates, and pebble-beds. In one little quarry, near Pocket Gate, some circular markings were found which gave rise to much discussion. They lie on the bedding-planes, which here coincide with the cleavage, and consist of alternate ridge and furrow. The largest measures twelve inches by ten; in the opinion of Mr. Bonney they are concretionary only. As to the age of the rocks of the Charnwood Forest region, the Directors appeared unanimous in assigning them to the Silurian System. They are coloured as Cambrian by the Geological Survey, whilst by some geologists they are considered to be Laurentian. In the absence of fossil evidence and that afforded by superposition, the question is at best but a balance of probabilities.

Thence driving quickly through Woodhouse and Quorndon, the famous granite quarries at Mountsorrel were reached at 5 p.m., and Mr. Hambly, F.G.S., the courteous Managing Director, kindly showed the way over the works. The working "face" is nearly half a mile in length, and about six hundred men and boys are usually employed. The stone contains pink and

white felspar, bottle-green hornblende, and a little mica. The presence of the latter mineral entitles the rock to be called a hornblendic granite. The face forms a conspicuous object from the Midland Main Line between Barrow and Sileby; but the old windmill which formerly crowned the spot, and was a noted land-mark, has lately been removed, owing to the progress of the works. In a side cutting at the northern end the relations of the Red Marl to the granite are admirably seen. The marls here are much ripple-marked, and contain large fragments of granite. The slope of the hill shows the granite well polished and striated—the effect probably of both sea and ice action. *Molybdenite* occurs here, and there is a large basaltic dyke crossing the face, which subsequently seems to have been broken up, as it is in a brecciated and rubbly state. After witnessing the breaking up of some large masses of granite by means of charges of powder and dynamite, the party ascended the hill. On the top there is a very typical felsite dyke, seven or eight inches thick, which cuts sharply through the granite. But a hasty departure had now to be made, and, driving rapidly, Leicester was reached about 7 p.m. Just before entering the town a "learned doctor" was picked up, who had lost the party near the Monastery, and had since been hastening on under the impression that he was left behind!

Thus ended the Whitsuntide Excursion of 1877. On the first day it included about 25 miles, and on the second day about 35 miles of driving and walking. A fair amount of time was allowed for the inspection of every point visited, and when the farewells were said on the platform of Leicester Station, the general verdict was a favourable one.

ORDINARY MEETING, June 1st, 1877.

William Carruthers, Esq., F.R.S., Vice-President, in the Chair.

The following Donations were announced:—

"Abstracts of the Proceedings of the Geological Society," Nos. 336-337; from the Society.

"Journal of the Society of Arts," May, 1877; from the Society.

"Transactions of the Manchester Geological Society," Vol. xiv., Parts 9-10; from the Society,

"Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire," New Series, Part 3; from the Society.

The following were elected Members of the Association:—

Ernest Candelier, Esq.; Timothy Curley, Esq., F.G.S.; Thomas Jones, Esq., F.G.S.

The following Papers were read:—

1. On the Insect Fauna of the Tertiary Period and the British and Foreign Strata in which Insect Remains have been detected.

By Herbert Goss, Esq., F.L.S.

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2. On the Forms of the Genus Micraster common in the Chalk of West Kent and East Surrey.

By Caleb Evans, Esq., F.G.S.

The Chalk with bands of flint nodules is characterised in West Kent and East Surrey by the great number of Echinoderms belonging to the genus *Micraster* that it contains, and a brief notice of the distinctive characters of the forms of that genus* common in the Chalk in the neighbourhood of London, and of the stratigraphical position in which these forms are found may, therefore, be of some use.

In Professor Morris's Catalogue, 2nd Edition, the following list of forms of *Micraster*, met with in the English Chalk, is given:—

Micraster acutus.
" *cor-anguinum.*
" " variety *rostratus.*
" " variety *gibbus.*
" *cor-bovis.*
" *Mantelli.*

* For a general description of the Echinoderms of the Chalk see Mantell's "Medals of Creation," and other works.

A valuable description of *Micraster cor-anguinum*, the typical species of the genus, was published by the late Professor Edward Forbes, in Decade V. of the "Memoirs of the Geological Survey," and a complete Monograph of the genus is in course of publication by Dr. Wright, in the series of the Palæontographical Society.

The shell of this species is tolerably substantial, and is distinctly heart-shaped, as the furrow on the anterior side is deep, and the mouth is situated very near to the anterior margin of the under side. The lateral ambulacral areas are moderately depressed, and have a longitudinal groove extending down the centre of each depression, and transverse grooves extend from the central one to the margins of the ambulacra, and in these transverse grooves the pores are situated. The shell of this form is somewhat variable in shape, but by one or other of these characters the species may be recognised. The variety *rostratus* is very common, and is composed of those specimens in which the edges of the posterior interambulacral plates are somewhat raised, and form a kind of keel from the apex to the posterior end of the shell. In the variety *gibbus* the posterior interambulacral plates are depressed, giving a more conical shape to the shell. This form is less common than the typical form or the variety *rostratus*.

With regard to *Micraster acutus*, Professor Forbes observes* that it is difficult to understand how it is to be separated from *M. cor-anguinum*, and that it is "a specimen of the normal form in which the caudal extremity is slightly more produced than usual, a variety not uncommon."

Of *Micraster Mantelli* Professor Forbes observes that "the specimens with this name attached do not differ in any respect from those recognised as the young of *M. cor-anguinum*. At this age they are always very tumid, and the dorsal ambulacra are scarcely at all depressed."

A more distinct form is that described by Professor Forbes† under the name of *Micraster cor-bovis*. This form is not uncommon in the lower part of the Chalk with flints. It equals and even surpasses *M. cor-anguinum* in size, but it can be well distinguished from the last-mentioned form by its more elongated shape, by the thinness of the shell, by the more delicate character of the

* "Memoirs of the Geological Survey," Decade V.
† Dixon's "Fossils of Sussex," Plate xxiv., and Decade iii.

tubercles, and especially by the ambulacral areas being without ridges or furrows.

Among the various forms of *Micraster*, noticed by Professor Forbes, is one which has been described by Goldfuss,* and has been recognised by Continental geologists under the name of *M. cor-testudinarium.* Of this form Professor Forbes remarks that it is "a very slight variety of the normal form" of *M. cor-anguinum*, "constructed out of specimens having the mouth slightly further back than usual, a feature not unfrequently seen in depressed specimens." This form is further distinguished by the anterior furrow being shallower, and the lateral ambulacral areas deeper than in the normal form.

The typical form of *Micraster cor-anguinum* is common in the Chalk of Gravesend, and also in that of Charlton. At both these localities an echinoderm of another genus, *Galerites albo-galerus* (known to continental geologists as *Echinoconus conicus*) is very common, and is characteristic in West Kent and East Surrey of the Chalk immediately below the Tertiary beds, being found in that position at Lewisham, Chiselhurst, Keston, and Croydon, but it appears to be rare or absent in the lower portion of the Chalk with flints.

In a paper read before the Geologists' Association, on 7th January, 1870, I described some sections of the Chalk with flints seen in the unfinished cuttings of the Surrey and Sussex Railway near Purley and Kenley, villages between Croydon and Caterham. The Chalk in the sections at Purley is probably lower in the series than that of Gravesend and Charlton, since the Tertiary beds are only seen on the highest part of the hills by Sanderstead, while the Purley sections are more than 100 feet below the level of the junction of the two formations. From the Railway sections in the neighbourhood of Purley and Kenley I obtained a large number of specimens of *Micraster cor-anguinum*, and, after comparing these with the figures and descriptions published by Professor Forbes, I considered them to belong to the form *Micraster*, and, under that name included them in my list of fossils from those sections. About the time that I was engaged in preparing that paper my attention was directed by the publication of Mr. Davidson's "Notes on Continental Geology" † to the fact that foreign Geologists had recognised

* Goldfuss, "Petrefacten."

† "Geological Magazine," p. 162, Vol. vi.

in France and Germany two zones of Chalk, characterised respectively by *Micraster cor-anguinum* and *M. cor-testudinarium*, but after comparing the specimens I had obtained from Purley with those from Kenley I failed to observe any distinctive characters between those of each of the two localities. Some time after my paper was published my friend, Mr. Meÿer, informed me that *M. cor-testudinarium* was the characteristic fossil of the Dover Chalk, and that the type-form of *M. cor-anguinum* occurred at Charlton, and on once more examining my specimens from the Purley and Kenley cuttings (the Chalk of which I believed to be on about the same horizon as the Dover Chalk), I found that not a single specimen was of the type of *M. cor-anguinum*, nearly the whole of them being of the form known as *M. cor-testudinarium.* This fact is so striking, and has so important a bearing on the correlation of the sub-divisions of the English Chalk with those established on the Continent, that I am anxious, as early as possible, to correct the error that I made in the description of the Purley and Kenley railway sections, and in the list of fossils contained in my former paper, and to state that in every instance in which "*Micraster cor-anguinum*" is there mentioned as being present in those sections, the name "*Micraster cor-testudinarium*," or "*Micraster cor-anguinum*, variety *cor-testudinarium*," should be substituted.

With regard to *Micraster cor-bovis*, I have only found that form in the lowest part of the Chalk with flints, and I believe it is limited to that horizon, where it is associated with another echinoderm equally characteristic, *Holaster planus.*

The correction of the name of the characteristic fossil of the Purley and Kenley Chalk necessitates a modification of the classification I proposed for the Chalk of the line of sections between Croydon and Oxtead.

The lowest beds of the Chalk Marl were very imperfectly seen in the spoil heaps around the shafts of the long tunnel near Marden Park, but these beds are well exposed in the large pit in the escarpment of the North Downs, near Oxtead, a little to the east of the line of railway. The highest beds of Chalk of the district were not seen in the Purley railway-cuttings, but are exposed in Chalk-pits at Combe Lane and Crohamhurst, near Croydon.

The classification I am now disposed to adopt for the Chalk of

West Kent and East Surrey is as follows, commencing at the base of the Series :—

Zone of *Holaster* * *trecensis* and *Ammonites varians*—Chalk Marl and Grey Chalk—Chalk of Oxtead.

Zone of *Belemnitella plena*—Yellowish concretionary Chalk, and hard White Chalk—Lower Chalk of Marden Park.

Zone of *Inoceramus mytiloides* (*labiatus*)—White Chalk without flints—Upper Chalk of Marden Park.

Zone of *Inoceramus Brongniarti* and *Terebratulina gracilis*—White Chalk with few flints—Chalk of Whiteleaf.

Zone of *Holaster planus* and *Micraster cor-bovis*—lowest beds of Chalk with bands of flint nodules—Lower Chalk of Kenley.

Zone of *Micraster cor-testudinarium*—Chalk with bands of flints—Chalk of Riddlesdown (or Upper Chalk of Kenley and Chalk of Purley).

Zone of *Micraster cor-anguinum* and *Echinoconus conicus* (*Galerites albo-galerus*)—Chalk with bands of flints—Chalk of Croydon and Charlton.

The Chalk of Gravesend is, perhaps, slightly higher in the series than the Charlton and Croydon Chalk, as *Belemnitella mucronata* is common at Gravesend, the fauna in that respect approaching to that of the Margate Chalk.

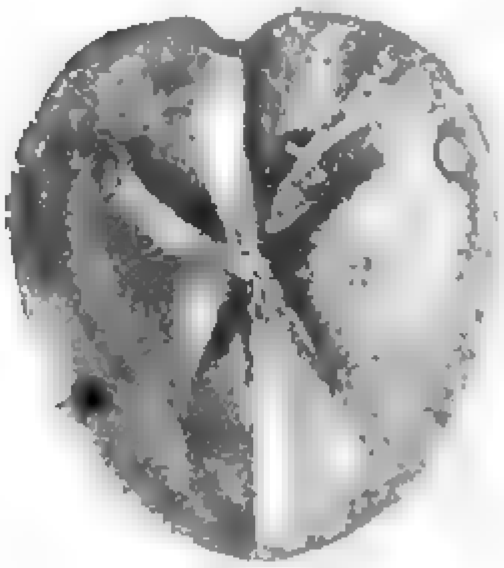
In the year 1876 a very valuable memoir on the Chalk of England and Ireland was published at Lille by Dr. Charles Barrois, in which that gentleman described the Chalk of the South Downs and the Hampshire Basin, and of most other parts of England, in so complete and masterly a manner, that little more remains to be done than the filling in of minor details ; and he has clearly shown that it is possible to identify in the English Chalk the zones which he has already established in the Chalk of France.

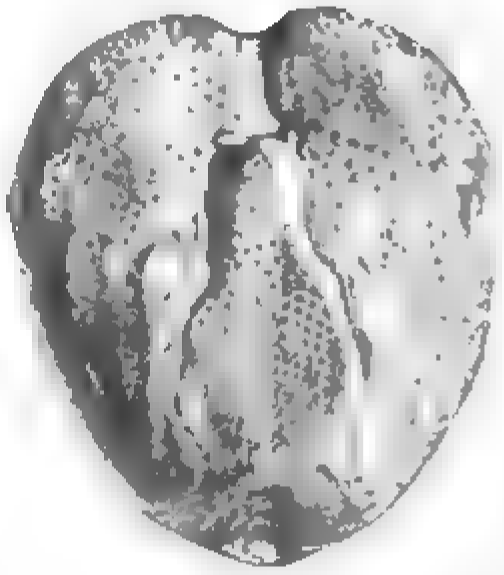
The classification which Dr. Barrois adopts is shown in the middle column of the following table. The left hand column shows the manner in which he has correlated his zones with those proposed by me in 1870 for the Surrey Railway sections, and in the column on the right hand I have shown the classification I am now disposed to adopt for the Chalk of East Surrey and West Kent :—

* *Holaster subglobosus* is usually adopted as the type of this zone, but I have not as yet obtained this fossil from Oxtead.

C. Evans (1870) Surrey and Sussex Railway Classification.	C. Barrois (1876) General Classification.	C. Evans (1877) East Surrey and West Kent Classification.
	Assise à Belemnitelles ...	Gravesend Beds?
Purley Beds	Zone à Marsupites	
	Zone à M. cor-anguinum...	Charlton and Croydon Beds.
Upper Kenley Beds...	Zone à M. cortestudinarium	Riddlesdown Beds.
Lower Kenley Beds .	Zone à Holaster planus...	Kenley Beds.
Whiteleaf Beds	Zone à Terebratulina gracilis	Whiteleaf Beds.
Upper Marden Park Beds	Zone à Inoceramus labiatus	Upper Marden Park Beds.
Lower Marden Park Beds	Zone à Belemnites plenus	Lower Marden Park Beds.
	Zone à Holaster subglobosus	Oxted Beds.
	Chloritic Marl	
	Zone à Pecten asper......	
	Zone à Ammonites inflatus	

Dr. Barrois states in his memoir that he has not had time to study the Chalk of the Basin of the Thames with the exactness with which he has examined the Chalk of the Southern parts of England, and he has relied to a great extent on the works published by previous writers on the subject, for the purpose of correlating the divisions of the Chalk near London with those established elsewhere. Among the works cited he has included my paper on the Croydon and Oxted Sections, and, trusting to the correct identification of *Micraster cor-anguinum* as the characteristic fossil of the Purley Chalk, he has, I believe, placed that Chalk on too high a horizon. I regret that the error I made in my list of fossils should have been the cause of thus misleading him, and I therefore desire, as early as possible, to correct my mistake, and to confirm his generalisation that the zones of life, which he has in so admirable a manner established for the Chalk of the Hampshire Basin, and in France, can be equally well recognised and studied in the Chalk of the Basin of the Thames.





B West ... del et lith

Micraster cor bovis Forbes

C. Evans (1870) Surrey and Sussex Railway Classification.	*C. Barrois (1876) General Classification.*	*C. Eva East Surr Kent Cl*
	Assise à Belemnitelles ...	Gravesend
Purley Beds	Zone à Marsupites	
	Zone à M. cor-anguinum...	Charlton a Beds.
Upper Kenley Beds...	Zone à M. cortestudinarium........................	Riddlesdow
Lower Kenley Beds...	Zone à Holaster planus...	Kenley Be
Whiteleaf Beds	Zone à Terebratulina gracilis	Whiteleaf
Upper Marden Park Beds	Zone à Inoceramus labiatus	Upper Mar
Lower Marden Park Beds	Zone à Belemnites plenus	Lower Mar
	Zone à Holaster subglobosus	Oxtead Be
	Chloritic Marl	
	Zone à Pecten asper......	
	Zone à Ammonites inflatus	

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W West & Co del et lith.

Micraster cor-bovis *Forbes*.

EXCURSION TO CATERHAM, GODSTONE, TILBURSTOW, AND NUTFIELD.

MONDAY, JUNE 4TH, 1877.

Director: J. LOGAN LOBLEY, ESQ., F.G.S.

(*Report by* MR. LOBLEY.)

Before arriving at Caterham, the party were much interested by seeing the "Bourne" flowing along the bottom of the usually streamless, but still beautiful, Kenley Valley. This intermittent river flows only after unusually wet seasons, the Chalk of the district absorbing ordinary rainfalls. In recent years there were flows in 1866, 1873, and a small flow in 1876. This year the flow is large, and is the subject of much comment and speculation amongst the residents of the locality, some of whom even now ascribe the appearance of the river to a mysterious or supernatural agency, although in 1660 the true cause was known. Childrey, in the "Britannia Baconica" of that year, says:—"The rising of a bourne or stream near Croydon (as the common people hold) presageth death or the plague; and it hath been observed to fall out so. The rising of the bournes in places where they run not always we have before proved to be caused by great wet years, which (according to Hippocrates' observation) are generally the most sickly; and if they prove hot as well as wet (because heat and moisture are the greater disposers to putrefaction), they prove also malignant, and, for the most part, pestilential. And the reason why the rising of this bourne doth not always presage the plague is because all wet years do not presage hot."*

Mr. Baldwin Latham, F.G.S., in a letter to the "Croydon Chronicle," dated January 25th, 1877, gives the following particulars of the flow of the present year:—"The flow of the Bourne from Marden Park and that at Riddlesdown joined each other on Monday, the 22nd inst., and now forms one continuous stream, and the flow is making rapid progress towards Croydon, having this day (Thursday) reached to a point north of Caterham Junction. The Bourne now makes its appearance at the highest

* "Memoirs of the Geological Survey of Great Britain, Geology of the London Basin." By W. Whitaker, F.G.S., p. 391.

point a short distance below Bughill Farm, and from this point to a considerable distance below the Rose and Crown Inn, under Riddlesdown, the water continuously receives considerable accessions to its bulk. The volumes flowing from Marden Park, at Wapses Lodge, have been as follows :—

" On the 19th,	at the rate of	1,516,000	gallons	in 24 hours.			
" " 20th	"	"	2,567,000	"	"	"	
" " 23rd	"	"	4,421,000	"	"	"	
" " 24th	"	"	4,623,000	"	"	"	

" At this latter date the volume below the Rose and Crown was flowing at the rate of 10,584,000 gallons in 24 hours, while at Warlingham Station, a point intermediate between Wapses Lodge and the Rose and Crown, the volume flowing was at the rate of 6,855,000 gallons in 24 hours. From my last letter it will be seen that the volume of water flowing out of the Bourne Culver, at Croydon on the 15th inst. was at the rate of 9,300,000 gallons in 24 hours. On the 21st it was at the rate of 8,837,000 gallons in 24 hours, and on the 24th inst. at the rate of 8,761,000 gallons in 24 hours. The falling off of the quantity is no doubt due to local effects arising from the diminution of the rainfall."

On alighting from the train at Caterham, the Members were gratified at finding that a collection of the fossils of the Chalk of the neighbourhood had been brought by Mr. Cluse, of Caterham Junction, not only for inspection, but also, with great liberality, for distribution amongst those of the party who did not possess specimens of the species exhibited. At a short distance from Caterham Station, on the road to Godstone, a visit was paid to a quarry in the Lower Chalk, and here the Director explained that they were now in the region of the North Downs, and that from Caterham Junction to Caterham, lower and lower beds of the Chalk had been traversed, the section at the Junction showing Mr. Caleb Evans' Upper Kenley, or Riddlesdown, Beds of the Upper Chalk, while this quarry was in the Lower Marden Park beds of the Lower Chalk. These beds are characterised by *Belemnites plenus* and *Holaster subglobosus*. An energetic exploration of the Chalk exposed did not, however, result in many organic remains being found, and these were chiefly fragments of *Inoceramus*. An explanation of the intermittent flowing of the Bourne river was accompanied by the presentation by Mr. Taylor, a Member of the Association, to each of the party of a copy of the article on

the subject in the "Geology of the London Basin," p. 391, a large number having been printed by that gentleman for distribution on this occasion.

Heavy rain arrested progress for a little time, but on its cessation the party speedily made their way to the great Firestone quarries in the Upper Greensand, on the Godstone road, which have been worked underground for a long period, though they are not so ancient as others a little distance to the west, from which stone for Windsor Castle was obtained in the time of Edward III. By the kindness of the Manager, the Members were provided with candles, when the galleries were entered by almost the whole of the party, and explored to their furthest extremities, where the actual hewing of the blocks or slabs of the Firestone was being actively prosecuted. Though at the ends of the workings there are places in which a considerable quantity of water lies, the galleries, along which trams are laid, are comparatively dry. A considerable time was spent in the workings, and the Members were glad to emerge into the warm sunshine after the cold dampness of their subterranean visit. The Firestone is quarried from a calcareo-siliceous bed of the Upper Greensand, which has an extension not limited to Surrey, since it is worked as far west as Wantage, in Berks. Curiously enough, however, near to the opening to the quarries another excavation had been made, but no Firestone had been met with. At this place some fossil sponges, *Siphonia*, were found by two or three Members. Under the guidance of the Manager of the Quarries, a visit was paid to a quarry near Marden Park, in which a harder stone, used for hearthstones, occurs. Proceeding southwards, an exposure of the Gault was found in a field to the east of the Godstone road, and a few fragments of the characteristic *Belemnitella minima* were extracted from the clay. After passing a pit in which a fine white sand is worked, an exposure of Lower Greensand, the pretty village of Godstone was entered, and at the picturesque roadside inn the party stopped to enjoy a substantial luncheon.

After luncheon the road to Tilburstow Hill was taken, and a "head-water" of the Medway, Broad Mead Water, having been crossed, the ascent of the commanding elevation of Tilburstow commenced. A deeply-cut disused lane, almost covered by tangled vegetation, opens on to a fine breezy expanse on the hill side, and here the party paused, and, turning to the north, sur-

veyed the beautiful valley they had just crossed, lying between Tilburstow Hill on which they stood and the Chalk hills of the North Downs. The bare, but green Chalk hills on the opposite side of the valley, diversified with white patches where excavations occur along their sides, contrasted with the darker green and well-wooded lower ground of the Upper Greensand and Gault. The Lower Chalk of Caterham had given place to the Upper Greensand of the Firestone Quarries, and this had been succeeded by the Gault of the bottom of the valley and the Lower Greensand, the commencement of which had been seen at the Godstone sand-pit, and of which the whole of Tilburstow Hill was composed. Thus a regular and continuous sequence of beds had been traversed from Caterham Junction to the spot on which they stood.

Continuing the ascent, the party soon reached the summit of the road, where a fine section of the ferruginous sands of which the Lower Greensand so largely consists, is exposed. The tendency of the oxide of iron to separate from the sand and form "boxes" is well exemplified at this place, and some good specimens of these structures were obtained. The top of the hill is much higher than the summit of the road, and is only gained by a very steep and difficult path; but the difficulty was soon overcome by the enthusiasm of the Members, who one by one emerged from the brushwood and stood on the little plateau under the trees which crown the summit of Tilburstow. Those who had not previously visited this spot were struck with the extent and extreme beauty of the landscape which met their eyes, for, stretching to the east and stretching to the west, and extending to the south as far as the eye could see, lay before them the great Wealden Valley, with its verdant pastures, its orchards, and its woods glorious with the foliage of the leafy month of June, all bathed in the sunshine of a bright summer day. With the aid of the Geological Survey Maps, embracing the entire Wealden Area, the Director described the physical features of this great valley of upheaval bounded by the North and South Downs—the middle of which, the Forest Ridge, being higher than the sides—and explained the theories held to account for the denudation of the great mass of Cretaceous strata which had been removed. Mr. Boulger having said a few words on the plants of the neighbourhood, the party left the hill top, and after visiting some Kentish Rag quarries in the Lower Greensand,

made their way westward along the hill, through the villages of Bletchingley and Nutfield, to the well-known Fuller's-earth pits, also in the Lower Greensand. The argillaceous earth here worked is finer than that of the formation called the Fuller's Earth, and is largely used in the arts. Masses of barytes occur in these pits, and, when broken up, show fine brown crystals, sometimes having small cubical crystals of iron pyrites attached. Nearly every member of the party succeeded in carrying away a good specimen.

A further walk of about a mile brought the party to Redhill, where the now tired Geologists gathered round the tea-table of the hotel, and, after the usual compliment to the Director, took the train for London.

Mr. C. J. A. Meÿer, F.G.S., whose intimate acquaintance with the Lower Greensand of Surrey is well known, has kindly furnished the following list of fossils obtained from the Nutfield Lower Greensand :—

Nautilus undulatus (Sow.)
Ammonites Nutfieldensis (Sow.)
„ consobrina (D'Orb.)
„ sp.
Pleurotomaria Anstedi (Forbes).
Natica sp.
Venus Vectensis (Forbes).
Trigonia ornata (D'Orb.)
„ Archiaciana (D'Orb.) (?)
„ Vectiana (Lycet).
Nucula, two or three species.
Pholadomya Rauliniana (D'Orb.)
Panopæa nana (Coquand).
Panopæa Prevostii (D'Orb.)
Mytilus.
Lima Cottaldina (D'Orb.)
Inoceramus sp.
Plicatula Carteroniana (D'Orb.)
Pecten, allied to P. Milleri (Sow.)
„ near to.
Janira Morrisii (Picket).
Exogyra Tombeckiana (D'Orb.)
Hemipneustis Fittoni (Forbes), common.
Cone of Pinites.
Fragments of Wood—abundant.

EXCURSION TO HAMPSTEAD.

JUNE 16TH, 1877.

Director—CALEB EVANS, ESQ., F.G.S.

(*Report by* MR. EVANS).

Hampstead Heath, to which excursions have been made by the Geologists' Association on several occasions during the last few years,* was again visited. Proceeding from the Swiss Cottage Railway Station, along Fitzjohn's Avenue—a new road on the site of the footpath across the Conduit Fields—the Director explained, with the aid of diagrams, the geological structure of the district within view (on a clear day) from that spot, comprising the valley of the Thames; the high grounds of Clapham, Wandsworth, Wimbledon and Richmond, composed of London Clay capped with gravel; the high hills of London Clay, on which the Crystal Palace is situated; and the yet higher range of the Addington Hills near Croydon, composed chiefly of thick pebble beds of the Oldhaven Series, the prospect being bounded to the southward by the Chalk hills of the North Downs.

Attention was also directed to the ridge of Palæozoic rocks believed to exist beneath the Upper Cretaceous rocks of the London area, evidence of which had recently been met with in the deep well boring at Messrs. Meux's Brewery, in Tottenham Court Road.

The absence of any clear sections of the Lower Bagshot Sand or of the London Clay obliged the party to confine their attention chiefly to the geological structure of the surrounding district, and having proceeded to the top of the hill by the flagstaff, the positions were pointed out of Harrow-on-the-Hill with its small outliers of the Bagshot Sand, of the high ridges above Stanmore, Elstree, Highwood Hill and Mill Hill capped with patches of Pebble-gravel of doubtful age, and of the intervening district around Hendon and Finchley, on which Glacial deposits yet remain. From the neighbourhood of North End the difference was noted between the prospect to the northward, where the district occupied by the Glacial deposits presents the appearance of a wide and level plateau as far as the eye can reach, and the view to the northwest of Hampstead, where the country is composed of London Clay with small cappings of sand or gravel, and is more diversified

* See Proc. Geol. Assoc., Vol. ii., p. 40; Vol. iii., p. 67; Vol. iv., 155.

by detached hills and intervening valleys. In the immediate neighbourhood of the Heath the diverging valleys occupied by the Hampstead and Highgate ponds, forming the headwaters of the Fleet river, were noticed, as probably resulting from the outflow of springs at the junction of the London Clay with the Bagshot Sands. Examples of these springs were well seen at the Vale of Health, and at Well Walk, and after tasting the chalybeate water at the latter spot, the party proceeded to the residence of the Director, and examined his collection of Tertiary fossils, many of which were obtained by him in the neighbourhood of Hampstead.

EXCURSION TO GUILDFORD.

JUNE 25TH, 1877.

Director—R. A. C. GODWIN-AUSTEN, Esq., F.R.S., &c.

(*Report by* C. J. A. MEŸER, Esq., F.G.S.).

On this occasion Members assembled at Chilworth Station, where they were met by Mr. Godwin-Austen. After a few words as to the proposed course of the Excursion, the party proceeded to examine a bed of Elephant-gravel exposed in a new road-cutting. This gravel, which formed an eastern extension of the Peasmarsh valley-gravel, was observed to consist largely of unrolled and broken flints, mingled with fragments of the Bargate-stone, Chert, and Carstone (Ironstone), of the Lower Greensand. It contained apparently neither rounded flints nor Tertiary pebbles. The gravel rested here on Hythe Beds; further westward it covered both Atherfield Clay and Weald Clay.

The Tillingbourne stream, which was presently crossed on the way towards St. Martha's Hill, was described as running partly on the Weald Clay and partly on the Atherfield Clay, or lowest member of the Surrey Greensand. At the foot of St. Martha's Hill the party separated into two groups:—One with Professor Morris, taking the shortest path to the hill top; the other and more enterprising, under Mr. Godwin-Austen, taking a longer route, with the chance of finer sections. At the top of St. Martha's and while waiting for the re-union of the party, Mr. Meÿer described briefly to those present the succession of the strata in-

cluded in the Surrey Greensand. On mounting the hill, they had passed over in succession the outcrop of the Atherfield Clay, Hythe Beds, Sandgate Beds, and Folkestone Beds of the Lower Greensand. The Atherfield Clay (first noticed in England by Mr. Godwin-Austen in 1843)* is here very rich in fossils in its lowest beds, which are most unfortunately, however, very rarely exposed. The Hythe Beds and Sandgate Beds exhibit by comparison a singular dearth of fossils—*Exogyra sinuata*, *Hinnites Leymerii*, *Terebratula sella*, an *Ammonite* or two, and a species of *Belemnite*, probably completing the list of those obtainable in this district. The pebble-bed and Bargate-stone series, forming the base of the Folkestone Beds, contains a fauna, remarkable chiefly for its wide range, and from its differing so entirely in this district from that of the lower beds. The ferruginous sand, with "Carstone" capping the hill on which they stood, was wholly unfossiliferous. This sand-bed had here a thickness of about 130 feet. In the Isle of Wight, where it was also unfossiliferous, its thickness was even greater. At Folkestone, curiously enough, it was almost entirely absent; its position being there held by a detrital bed of about one foot only in thickness.

The Members having now again collected, Mr. Godwin-Austen described to an attentive audience the leading geological and physical features of the great Wealden anticlinal with its margin of Chalk and Greensand; pointing out especially the relation of the English Wealden and Lower Greensand to the Neocomian rocks of France and Switzerland. Commenting at some length on the discovery of Devonian rocks beneath London, as proved by the recent well-boring at Meux's brewery, he traced their probable and almost certain connection with the Palæozoic rocks and Coal Measures of Belgium, the North of France, and the coal area of Bristol.

Turning now towards Guildford, the Warren Farm Section of highly inclined Grey Chalk and Chalk Marl was next visited; specimens of *Nautilus elegans*, *Terebratula obesa*, and *Inoceramus* rewarding the search for fossils. The two Chalk pits in Quarry Street were also briefly visited. The lowest of these contains but few fossils only of the zones of *Inoceramus labiatus*, *Terebratulina gracilis*, and *Holaster planus*. The larger and higher quarry embraces a section displaying the zones of *Holaster planus*,

* "Proc. Geol. Soc.," Vol. iv., pp. 167, 196,

Micraster cor-bovis, and *M. Desori* (?); and, in great force, the zone of *Micraster cor-testudinarium*, with many of their associated fossils. Sponges and cone-like pressure-striated concretions abound in both quarries on certain limited horizons. Time did not now, however, allow of a search for specimens.

On reaching Guildford the Members took carriages for the drive to Seale Rectory, near Farnham, the course taken being along the top of the Hogsback. The fineness of the day, and beauty and wide range of the view obtained during the drive must have rendered it one of pleasant memory to all concerned. To the geologist it was interesting to observe the subtle differences in outline and fertility of the country to North and South of this dividing ridge of Chalk. Rich foliage and high culture to the northwards indicating the position of the Tertiary, Woolwich and London, Clays and Sands, backed by the gloomy heath or fir covered hills of the Bagshot Sand, spreading out westwards towards Aldershot. To the south, again, heath lands, dark fir woods, and strips of corn land, mapping the outcrop of Neocomian clay, sand, or limestone. Yonder was Beech-covered Hascombe Hill overlooking the Weald. Yonder Hind-head and the Devil's Punch Bowl; the latter a striking monument of subaerial denudation. Yonder Carstone-capped Crooksbury. Yonder Kettlebury and the once sandy waste of Thursley and Frensham Commons. Further away Alder Holt Forest, with the widest continuous spread of Gault in England. And yonder a glimpse of hills about Selbourne.

At Seale Rectory, snugly situate under the sunny side of the Hogsback, the now hungry party was entertained most hospitably by the Rector (the Rev. T. T. Griffith), a Member of the Association. A spirited address by Professor Morris, embodying a cordial vote of thanks to their leader and to their entertainer, and the examination of a series of fossils illustrative in part of the country traversed, brought the day's proceedings most pleasantly to a close.

ORDINARY MEETING, July 6th, 1877.

Professor Morris, F.G.S., President, in the Chair.

The following Donations were announced:—

"Quarterly Journal of the Geological Society," Vol. xxxiii., Part 2 (May); from the Society.

"Abstracts of the Proceedings of the Geological Society," No. 338; from the Society.

"Transactions of the Watford Natural History Society and Hertfordshire Field Club," Vol. i., Part 7 (July); from the Society.

"Proceedings of the Dorset Natural History and Antiquarian Field Club," for 1876; from the Society.

"Journal of the Society of Arts," June, 1877; from the Society.

"Canadian Journal of Science, Literature, and History," Vol. xv., No. 5 (April).

"Annual Report of the West London Scientific Association and Field Club for 1876-7;" from the Association.

"Annual Report of the Royal Cornwall Polytechnic Society for 1876;" from the Society.

"List of Members of the Institute of Civil Engineers," 1877; from the Institute.

"On the Brachiopoda of the Inferior Oolite of Bradford Abbas and its Vicinity," by Thomas Davidson, F.R.S., &c.; from the Author.

"On the Variation in Thickness of the Coals and Measures of the Lancashire Coal Field" (Part 1), by C. E. De Rance, F.G.S.; from the Author.

"Second Report of the Committee for Investigating the Circulation of the Underground Waters in the New Red Sandstone and Permian Formations of England," by C. E. De Rance, F.G.S.; from the Author.

The following were elected Members of the Association:—

Frank Manley Bendall, Esq.; S. J. Bendall, Esq.; A. C. Dixon, Esq., F.C.S.; Herbert A. Langridge, Esq.

The following Paper was read:—

On the Geology of the Eastern Portion of the Banbury and Cheltenham Direct Railway.*

By Thomas Beesley, Esq., F.C.S.

Nothing has, of late years, done more for the study of local Geology than the extension of railways. In the course of the great works necessary to the system, sections have been opened that, if not so deep and extensive as those afforded by some of our coasts, are far better adapted for measurement and the collection of their fossils; and the geologist as he passes swiftly by, may, from the windows of a railway carriage, get a knowledge of the more salient characteristics of a formation, often more valuable than the teachings of books. When thus travelling, it has occurred to me that a work might be written upon the geology of our railways, noticing the sections in their order, and taking in the surface indications and physical geography where practicable, which would be interesting and useful to young geologists, and not altogether to be despised by experienced observers. In my own neighbourhood are several such sections worthy of notice; some of them, as the great cutting through the Lower Lias at Harbury, well known. Lately I have described with some particularity a section in the *Jamesoni* zone of the Middle Lias at Fenny Compton,† also on the Great Western, between Banbury and Leamington; and there are good sections of the Great Oolite between these towns and Oxford. The great bones of *Cetiosaurus*, now in the Oxford University Museum, were partly obtained from this formation, close to the Kirtlington Station.

During the last two years a new line, to be called the "Banbury and Cheltenham Direct Railway," has been in course of construction; and the eastern portion of it, starting from King's Sutton, the nearest station on the Great Western Railway, south of Banbury, and passing through or near the villages of Adderbury, Milton, Bloxham, Milcomb, Hooknorton, and Rollright, to the town of Chipping Norton, has afforded such interesting sections, that your esteemed President, Professor Morris, who last summer

* All the localities mentioned in this paper occur in Map No. 45 N.W. of the Ordnance Geological Survey.

† "The Lias of Fenny Compton, Warwickshire," by Thomas Beesley, F.C.S. (Proceedings of Warwickshire Naturalists' and Archæologists' Field Club," 1877.)

did me the honour to visit some of them in my company, has called upon me to briefly describe them for your information.

And here I must ask you to bear in mind that some of the localities most deserving of notice are distant several miles from my place of residence, so that I have been unable to observe their features as fully as I might otherwise have done. This, I trust, will be accepted as some excuse for shortcomings in my account of the imaginary journey which I shall now ask you to make with me.

Some of you may have noticed, when travelling on the Great Western Railway, and nearing Banbury from Oxford, a church with a tower and very elegant spire of the 15th century, the latter richly ornamented with foliated crokets upon its angles, standing upon a gentle eminence above a village station. This is the church of King's Sutton, said by tradition to have been built, at any rate so far as the tower and spire are concerned, by the famous William of Wykham, who held large estates in these parts, and took his name from a village near Banbury. I could tell you many things of archæological interest about King's Sutton, but I refrain, as doubtless you despise matters of so very recent a date. I may, however, just say that in early Saxon times, A.D. 662, a saint was born here, St. Rumbald by name. He lived but three days, but nevertheless found time to *preach* at Brackley, six miles off, whither his body was translated in the following year. He had a chapel here dedicated to him, and also gave his name to a Holy Well, the once somewhat celebrated Astrop Well, at one time much frequented.

The church stands upon the Marlstone or Ironstone, the *Spinatus* zone of the Middle Lias, which about here is richly fossiliferous, and has yielded several new species, as well as some hitherto only known from similar beds in Normandy. Amongst the new species are several corals, lately described at a meeting of the Geological Society, by Mr. R. F. Tomes, and a Crania (*C. Griffini, Dav.*). The line of railway, which runs along the low ground of the Cherwell valley, is upon the *Margaritatus* zone, a slight section of which is visible near the bridge just south of the station. Here occurs *Cryptænia complanata, Desl.*, which in these parts seems to take the place of the common *Cryptænia expansa*, a far less noticeable species.

The new line leaves the Great Western just beyond the bridge, curves westward as it crosses the Cherwell and the Oxford canal;

rising gently, passes the extreme east of Adderbury in a ...ng of 12 feet deep, where this section is seen:—

	Ft.	In.
Marlstone (*Am. spinatus*)	2	0
Sandy Shale	4	0
Sandy Marlstone (*Am. margaritatus*)...	2	0
Pale blue sandy Clay	4	0

...he stone is much weathered.

...st above the railway, on the northern side, is a considerable ...ry, showing the *Spinatus* beds, capped by 2 or 3 feet of ...er Lias, much broken and disturbed by a succession of little ...s into columns of a few feet wide, dipping in all directions; the ...s being filled with the grey Upper Lias clay, and fragments of ...white marly limestones of the *Serpentinus* zone—the "Upper ...alopoda beds" of Mr. Charles Moore. A few hundred yards ...er north is a very extensive ironstone quarry in the same beds; ...astern part similarly capped and faulted. At the top of the ...stone is a transition band of less ferruginous stone, probably ...*nnulatus* zone, although the characteristic ammonite has not ...found in this part of the country; its place seems to be taken ... *Holandrei*. This is very rich in fossils, especially gasteropods. ...e at some future time to describe them more fully than was ...in my "Sketch of the Geology of Banbury,"* some years ago. ...little beyond the bridge, on the road to Aynho, the cutting ...s, but at the second, or Oxford-road bridge, another and ...r cutting begins; and here the whole depth of the *Margaritatus* ...is seen. At the top is the broken *Spinatus* rubble; then ...s the upper *Margaritatus* stone, a rather siliceous Marlstone ...ncretionary blocks, with much calcite, 2 feet thick—brown ...e weathered, but blue where preserved from oxidation. Below ...we get 9 feet of sandy shale—the upper part light grey, the ... pale blue—resting upon another row of concretionary blocks, ...r more argillaceous than the upper ones, and apparently less ...iferous. Beneath are the dark blue laminated clays of the ...*Cornus* zone, of which only a few feet are visible. As the ...sinks down, a fine view is got of the church of Adderbury, ...its 13th century tower and spire. Beyond, the line passes ...gh the extreme west of this village, and by the hamlet of ...n, towards Bloxham, marked in the distance by its magnificent

...A sketch of the Geology of the neighbourhood of Banbury," by ...s Beesley, F.C.S., in "Proceedings of the Warwickshire Naturalists' ...rchæologists' Field Club" for 1872.

tower and spire of early 14th century architecture, having thus brought the traveller within sight of the three finest churches of these parts.

On nearing Bloxham, about 300 yards before reaching the Barford-road bridge, a small fault brings down the Upper Lias about 4 feet against the *Spinatus* beds. For 100 yards further the banks are all Marlstone of this zone; then comes another fault dipping to the east, which throws down the Upper Lias to the base of the section, a depth of 15 feet; the white marly limestone of the *Serpentinus* beds, crowded with *Ammonites bifrons*, *A. communis*, *A. cornucopiæ*, *A. heterophyllus*, *A. subcarinatus*, and species of the *Serpentinus* group, with *Belemnites Ilminsterensis*, *B. regularis*,* and *Nautili*, now forming the floor of the line, and over it blue or green shale, 15 feet thick. The faults pass obliquely across the line from N.W. to S.E. The Upper Lias dips slightly to the west, but the line slopes at a higher angle, so that the Marlstone again comes in at the next bridge. Beyond Bloxham the railway runs upon Marlstone, or over the bottom beds of the Upper Lias, past Milcomb, towards Hooknorton. On the north side, the land rises to an elevated tract nearly 700 feet above sea level, and 200 feet above the line of road, occupied by loose sands of the Inferior Oolite of the Northampton type, with some rubbly sandy limestones at the base, containing fossils of the *Murchisonæ* zone. On the northern side of this high ground rises the river Stour, flowing westward to the Warwickshire Avon and the Severn. On the south of the line are the villages of South Newington and Wigginton, situate on the lower beds of the same formation, let down by parallel faults which stretch westward from the Cherwell nearly to Hooknorton, and produce a narrow valley, which carries the river Swere to join the former river. Near Hooknorton the line turns southward, and will have to be cut through a considerable hill of Marlstone, and then carried by a viaduct and embankment over a deep dell and a plateau of Marlstone, to the lofty hill south of the village.† Through this a cutting has been partly made, which, when completed, will be three quarters of a mile long, and for some distance 40 feet deep.

Here let us look back for a moment upon the country over which, for nine miles, we have been travelling. Summing up our

* The fossils of the Bloxham Upper Lias, which have been largely collected by myself and others, will be enumerated elsewhere.

† 700 feet above the sea, and 180 feet above the valley below.

observations, we shall see that our course has been mainly over the Marlstone, here highly ferruginous, the *Spinatus* zone of the Middle Lias, with only occasional excursions upon the Upper Lias. This is of some importance with regard to the future of the railway, as the rock bed of this zone contains from 20 to 30 per cent. of iron, and is from 10 to 12 feet in thickness. At King's Sutton we started at an elevation of 300 feet above the sea. The south hill of Hooknorton is nearly 700 feet; and the line of railway passing through it will be about 650 feet. For the future, until we approach Chipping Norton, our road will run through or over the Lower Oolites.

Over a portion of the Marlstone plateau, and of the slope of the Upper Lias above it, an embankment, 30 feet high, is already made by "tipping" over large oolitic blocks, brought from the cutting to which it forms the approach. Its weight has caused the wet Upper Lias clay to bulge out in great ridges at its base. On the sides of the cutting the strata dip irregularly northwards to the valley. The lower bed is dark blue shale, belonging to the upper part of the Upper Lias. There are a few concretions, but, with the exception of a couple of small ones, 4 or 5 feet from the top, no regular bands of them. The upper part is slightly sandy; but this is evidently caused by the percolating water having removed the lime of the limestone above. The thickness cannot be got with accuracy, as there is no complete exposure, and the irregular dip interferes with its calculation. I estimate it at 30 or 40 feet. About Banbury it is 100 feet; at Chipping Norton, 35 feet; at Charlbury, six miles S.E. of the latter place, 10 feet; and at Fawler, a mile further in the same direction, 5 feet. There is no trace of the so-called "Upper Lias Sands," so largely developed in Dorsetshire.

UPPER LIAS FOSSILS—HOOKNORTON.

Ammonites bifrons.	Belemnites subaduncatus.
,, communis.	Cucullæa.
,, fibulatus.	Inoceramus.
,, opalinus.	Modiola.
Belemnites breviformis.	Ostrea Erina, D'Orb.
,, Ilminsterensis.	Leda ovum.
,, inæquistriatus.	Thracia glabra.
,, regularis.	

In some places very fine crystals of selenite occur.

Above the Lias comes the Rock-bed of the Inferior Oolite, a sandy limestone, thick-bedded, and with open sandy joints; yellowish brown on the surface; often white and very oolitic within; sometimes blue at heart, and very hard and crystalline. The section is:—

		Ft.	In.
1.	More or less thick-bedded, rather sandy Oolite, a little disturbed	17	0
2.	Compact, concretionary, rather argillaceous, thick-bedded Limestone, blue at heart, joints sandy; surface irregularly undulated, covered with small oysters (sometimes in two beds)	3	0
3.	Blue Upper Lias Clay, with concretions; top yellow and slightly uneven	12	0
		32	0

The whole of the Inferior Oolite in this section probably belongs to the zone of *Ammonites Murchisonæ*; not to the type as it occurs near Cheltenham, but to the variety seen at Bredon and Ebrington Hills, at the northern extremity of Gloucestershire. Eastward we should find these beds changing their characters, becoming, between Hooknorton and Banbury, loose sands with unimportant rubbly limestones at the base; but the latter still retaining many of the characteristic fossils. Near Banbury a little ironstone may be seen; and a few miles further, in Northamptonshire, the ferruginous character is strongly marked in ferruginous sandstones and thick deposits of cellular ironstone. The estuarine origin of some at least of the beds may be seen at Hooknorton, in the drift-wood and other vegetable remains abundant in some of the more sandy blocks. For a more complete account of these changes, I must refer you to the admirable "Introductory Essay" to the "Geology of Rutland," by Professor Judd. I should mention that in this cutting we hardly reach the top even of the *Murchisonæ* or lower zone.

FOSSILS FROM THE ZONE OF AMMONITES MURCHISONÆ, HOOKNORTON.

Cetiosaurus (tooth).
Hybodus, Pycnodus, Strophodus } teeth.
Ammonites Murchisonæ *var.* (?) very large, 2½ feet.
Nautilus *sp.*
Belemnites giganteus.
Ostrea Marshii.
„ Sowerbyi.
Pecten articulatus.
„ demissus.
„ æquivalvis (?)
„ lens.
„ personatus.
„ texturatus (?) (virguliferus Ph. ?)

Belemnites gingensis.
„ insculptus.
Cerithium limæforme.
Chemnitzia *sp.*
Monodonta lævigata.
Pleurotomaria ornata.
Turbo capitaneus.
Astarte elegans.
„ excavata.
„ *sp.*
Avicula inæquivalvis.
Cardium cognatum.
„ gibberulum.
„ striatulum.
„ *sp.*
Ceromya Bajociana.
Cucullæa cancellata.
Gastrochœna tortuosa.
Gervillia acuta. (?)
Lima cardiiformis.
„ impressa.
„ pectiniformis.
„ punctata.
„ semicircularis.
„ *sp.* small, tuberculate.
Modiola cuneata.
Myacites abductus.
„ decurtatus.
„ dilatus.
„ æquatus.
„ peregrinus
Ostrea calceola (young),
Pholadomya fidicula.
Pinna cuneata.
Trigonia conjungens, *Lyc.*
„ Phillipsi.
„ pullus.
„ signata.
„ V—scripta.
Unicardium depressum.
Terebratula perovalis.
„ submaxillata.
Rhynchonella concinna.
„ quadriplicata.
„ subdecorata.
Polyzoa.
Serpula deflexa.
„ intestinalis.
„ tetragona.
Astropecten *sp.* (*Windoes.*)
Extracrinus *sp.*
Pentacrinus Milleri.
Pygaster semisulcatus.
Echinoderm (spines).
Isastræa Conybeari.
„ explanulata.
„ Richardsoni.
„ serialis.
Montlivaltia trochoides.
„ Delabechei.
Thamnastræa Defranciana.
Coniferous wood.
Algæ.
Rain pittings.

The summit of the hill for nearly half a mile is not yet cut through, but considerable work has been done on its southern slope towards "Duckpool Farm." For some distance the beds are horizontal, and this section is exposed :—

		Ft.	In.
1.	Soil and Rubble with oysters	2	0
2.	Sand	0	3
3.	Rubbly Stone	1	6
4.	Sandy Limestone with broken shells and *Serpulæ;* large oysters in a band at the top; *Trigonia costata, Lima cardiiformis*...	3	6
5.	Blue Clay	0	3
6.	Grey Sandy Limestone	2	0
7.	Sandy Limestone	1	0
8.	Upper Lias Clay.		

The beds here are less disturbed and weathered than those on the other side of the hill; and the Inferior Oolite lies at once upon the clay, without any admixture of sand. Its lower surface is often covered with "nagel-kalk." Suddenly, on the east side of the cutting, the beds curve upwards, carrying the Upper Lias to the surface. This continues for a little distance: then comes a fault with an apparent dip to N.E., bringing down the basement beds of the Great Oolite limestone slightly below the top of the Upper Lias, a displacement, probably, of 40 feet. Below the limestone is a series of sandy shales and clays, with one or two bands of indurated sand, reaching to the bottom of the section at this spot. Beyond the fault, the beds curve downwards at an angle of 15°, but gradually approach the horizontal; and 40 yards further on is another parallel fault, with an upthrow of 4 feet; which, with the slope of the surface, soon causes the Great Oolite to run out at the top; whilst another row of limestone blocks makes its appearance for a short space at the bottom of the section, of which Section Fig. 1 is a diagrammatic representation.

The detailed section at the point marked in Section, Fig. 1, is as follows:—

		Ft.	In.
1.	Great Oolite Limestone	3	0
2.	Brown sandy Clay	1	6
3.	Tough dark olive Clay	0	3
4.	Light sandy Clay (with snow-white calcareous concretions)	2	6
5.	Greenish-grey Sandstone	1	0
6.	Grey Clay	2	0
7.	Slaty Sandstone	1	0
8.	Brown Clay	2	0
9.	Blue Clay	2	0
10.	Inferior Oolite Limestone	1	0

The appearances on the north-west bank are represented in Section, Fig. 2.

The Inferior Oolite at the base is evidently a higher bed than any met with in the previous sections, and no fossils have as yet been found in it; but the limestone at the top, which I have attributed to the Great Oolite, has yielded me

Nerinæa punctata,
,, Eudesii (?)
Cypricardia Bathonica,
Cyprina Loweana,
Pecten annulatus,
Trigonia costata,
Rhynchonella concinna,
Clypeus Plottii,
Cidaris spines,

FIG. 1.—SECTION SOUTH-EAST SIDE OF CUTTING.

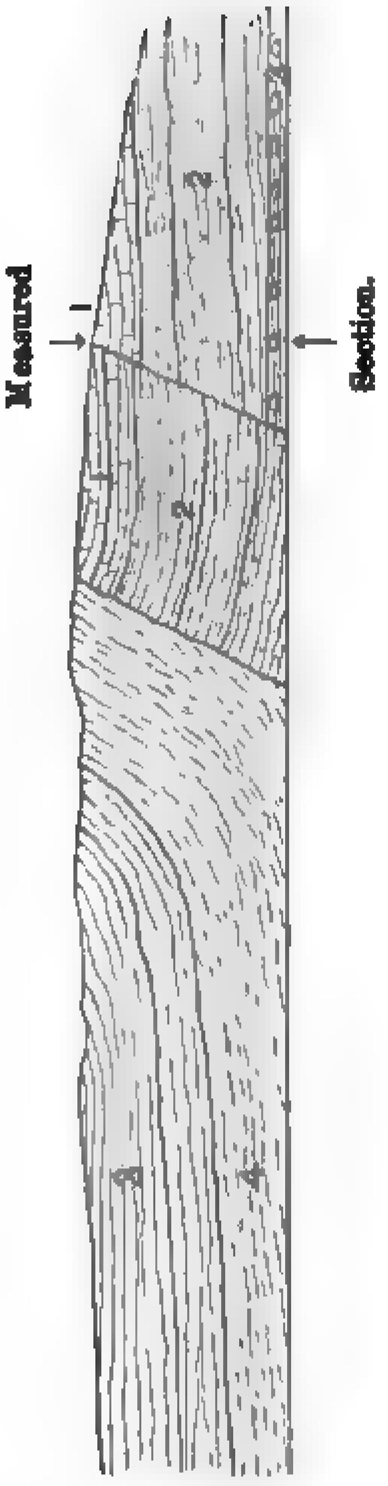
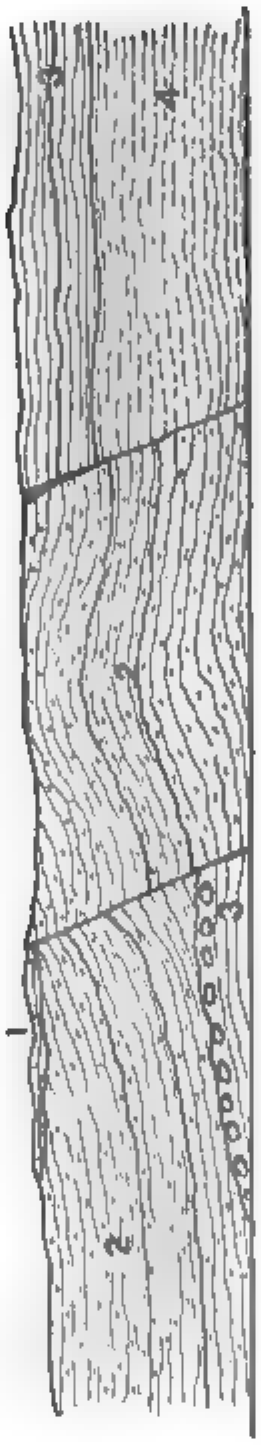


FIG. 2.—SECTION NORTH-WEST SIDE OF CUTTING.



1. Great Oolite.
2. Upper Estuarine.
3. Inferior Oolite.
4. Upper Lias.

which can leave no doubt about its geological position. The series of sandy clays must then be classed with the "Upper Estuarine beds" of Professor Judd. No fossils have been found in the upper part of them, but one or two imperfect ones in the sandstones, one a *Trigonia*, resembling *T. Moretoni*. In the bottom clay fossils are abundant, particularly *Ostrea Sowerbyi*, and *Rhynchonella concinna*.

LIST OF FOSSILS FROM THE UPPER ESTUARINE, HOOKNORTON.

Cypricardia Bathonica.	Pecten vagans.
Cyprina Loweana.	Placunopsis socialis.
Ostrea Sowerbyi.	Trigonia Moretoni (?)
„ acuminata (?)	Rhynchonella concinna,
„ subrugulosa.	Clypeus clunicularis.

Hitherto, these beds, except in a very reduced condition, and not clearly separable from the Lower Estuarines immediately below them, have been unnoticed in Oxfordshire. Two or three years ago, from an examination of some small openings for sand on Constitution Hill, a mile west of Banbury, I was able to prepare the following section :—

		Ft.	In.
1.	Grey slaty Limestone	3	0
2.	Brown Clay with decayed shells	0	4
3.	Coarse brown Sand	1	6
4.	Brown sandy Clay, with many decayed shells, and with vegetable stains below	0	4
5.	Rather compact black Sand, with carbonaceous fragments	2	0
6.	Brown Sand, white at top	6	0
7.	Rubbly Oolite, with Inferior Oolite fossils...	not known	

No. 1 seems to be a transition bed. Many years ago I recollect to have seen a fine impression of a large fern upon one of its slabs. 2, 3 and 4 are Upper Estuarine; 5 and 6 Lower Estuarine.

The fault, which lets down the beds just described, is marked on the map of the Geological Survey (No. 45, N.W.), as branching from another and longer one, a little north-east of Swerford. These run parallel for about four miles, in a W.S.W. direction, and three quarters of a mile apart, letting down the Great Oolite in a trough which forms the valley of the river Swere. Between these faults, on the northern slope, the line now runs; the undisturbed Inferior Oolite rising above it to table land, on the right, 700 feet above the sea; with a corresponding range, a mile distant, on the other side of the valley. We first pass over a short embankment,

which leads to a shallow cutting in the lower rocks of the Great Oolite. These dip a little to the west, and probably also more considerably to the south, but the trench is at present too narrow to observe this; and their original continuity with the beds at the top of the Estuarines which we have just left is clearly distinguishable. The stone is white, compact and marly, as is usual in Oxfordshire; and is very fossiliferous.

SECTION.

		Ft.	In.
1.	Marl	0	9
2.	Limestone	2	6
3.	Rubbly Limestone	4	0
4.	Limestone	2	6
5.	Sand	1	0
6.	Rubbly Stone	1	0
7.	Limestone, with corals	1	0
8.	Limestone	3	0
9.	Marl	Not known.	

No. 7 has a continuous band of corals in its upper half, the most abundant species being the branching *Thamnastræa Lyellii. Nerinæa* is abundant, and of several species. *Cypricardia Bathonica*, *Cyprina Loweana*, *Homomya Vezelayi*, *Myacites calceiformis*, *Mytilus imbricatus* and *M. Sowerbyanus*, *Ostræa Sowerbyi*, *Pholadomya Heraulti*, *Pecten annulatus*, and *Trigonia costata* are common. The section strongly reminds one of the same beds exposed in the lower part of the cuttings on the West Midland Railway, at Stonesfield and North Leigh, which the Association visited under the guidance of the late lamented Professor Phillips, three years ago.

After this comes a long embankment, and opposite Rollright Heath, another unimportant cutting in the Great Oolite, showing higher beds, with abundant *Cypricardias*. Through the greater portion of the next Oolitic hill, no work is done,* but as we get within a quarter of a mile of a bridge leading to Great Rollright, very near the spot where "Pest House" is marked on the map, we come suddenly upon a very interesting section. At the top is a bed or two of Oolite limestone, the upper full of *Terebratulæ*; and below a mass of grey or blue calcareous shales, with many thin and irregular blue calcareous bands, which at the bottom become thicker, and sometimes very hard, dark, and crystalline.

* A small and shallow excavation shows marly beds full of oysters, differing from *O. Sowerbyi*, and resembling those common in the Forest Marble.

Some of these calcareous bands, the upper surfaces of which are very undulating, are covered with curious impressions of the tracks of marine (?) animals; and amongst them are beautiful specimens of the "Zopfplatten," figured in Quenstedt's "Jura" (Tab. 46, fig. 1, p. 334), so called from the resemblance of the tracks to plaits of hair. Inclosed in one at least of the lower and thicker bands of indurated calcareous mud, is a layer of lignite, in large pieces, mostly coniferous wood in a fine state of preservation; and showing, when thin sections are examined under the microscope, most beautifully the "glandular" tissue. Some of this drift-wood is bored by mollusks, or covered with oysters and other shells. The beds are rather undulating in the section, rising in a gentle curve to the east, and have a general dip of 10° to S.S.W. The following is the section at the eastern end of the cutting:—

		Ft.	In.
1.	Soil and Oolitic subsoil	2	0
2.	Great Oolite Limestone	2	0
3.	Grey Shale, with thin stony bands	2	6
4.	Stone band	0	2
5.	Grey Shale	4	0
6.	Stone band	0	2
7.	Bluish grey Clay, with occasional stony bands ...	4	0
8.	Slaty Stone, in variable layers	2	0
9.	Clay, with much lignite	1	6
10.	Stone band inclosing much lignite, slaty and irregular at top, with many "tracks"	1	0

The stone bands are very variable, both in thickness and extent. In the grey beds, fossils, in a recognisable state, are not common, and mostly occur on the surfaces of the thicker and harder limestones. The most abundant seem to be *Ostrea Sowerbyi*, *Pecten vagans*, and *Placunopsis socialis*. The following species have been noticed:—

Tooth of Saurian.
Pycnodus.
Hybodus.
Teeth and scales of fish.
Cerithium Roissii (?)
Astarte *sp.*
Cypricardia Bathonica
Cyprina Loweana.
Lima duplicata.
" *sp.* small, with very fine striæ.
Mytilus furcatus.
Ostrea Sowerbyi.
Ostrea subrugulosa.
" acuminata (?)
Harpax (?)
Pinna cuneata.
Pecten annulatus.
" personatus.
" vagans.
Placunopsis Jurensis.
" socialis.
Trigonia costata.
" formosa (?)
ancredia truncata.

Terebratula maxillata.
Rhynchonella concinna.
Tracks of crustaceans (?)
Terebellaria ramosissima.
Stomatopora.
Serpula (3 *species*).
Cidaris Wrightii (?) (spines abundant).
Coniferous wood (bored).
Zopfplatten.

West of this section, as far as the Rollright Bridge, the banks are sloped and smoothed, so that only a mass of shale, with occasional thin platy bands, is visible; but just beyond the bridge the Great Oolite again comes in.

The appearance of the beds just described is so unusual in this part of the country, that I was at first, after a very cursory examination, inclined to attribute them to the "Upper Estuarines" of Professor Judd; and in this I seemed to be confirmed by the few fossils then found in the overlying white limestones, as well as by the petrological character of the latter, which seemed to point to the Great Oolite. However, three days before the reading of the present paper, I had the privilege of visiting the spot with Professor Morris and Mr. W. H. Hudlestone, F.G.S., who were of opinion that the grey beds represented a condition of the Forest Marble, not unusual in the South of England; and their view was fully confirmed by the discovery of Cornbrash fossils in the overlying white limestones, such as *Avicula echinata*, *Terebratula intermedia* and *T. obovata*.

The Great Oolite beyond shows the following section:—

		Ft.	In.
1.	Limestone	0	6
2.	Limestone, marly at top	1	6
3.	Blackish Clay	4	6
4.	Limestone	3	0

The dip is 5° south. No. 2 is exceedingly rich in fossils, especially gasteropods and small bivalves, as *Astarte*, in fine condition. The large *Chemnitzia Roissii* (?) is abundant. Some are, I think, undescribed. Splendid collections might be made here. The resemblance to the fauna of the Stonesfield and Northleigh beds is again apparent, but in this case it is to the higher beds of these places.

The following species have been found here:—

Fish teeth.
Actæonina parvula.
Cerithium quadricinctum.
„ Roissii.
„ *n.s.* (?)
Chemnitzia variabilis.
Monodonta, *sp.*
Natica canaliculata.
„ pyramidata.
„ Stricklandi.

Nerinæa Dufrenoyi.
„ Eudesii.
„ punctata.
„ „ *var.*
„ Voltzii.
Nerita minuta.
Phasianella acutiuscula.
Stomatia Buvignieri.
Trochotoma discoidea.
Trochus *sp.*
Anatina *sp.*
Avicula echinata.
Astarte angulata.
„ *sp.*
Cardium Stricklandi.
Ceromya Bajociana.
Ceromya Symondsii.
Corbis Lajoyei.
Corbula Hulliana.
Cypricardia Bathonica.
„ nuculiformis.
Cyprina Loweana.
Gresslya peregrina.
Isocardia *sp.*
Leda lachryma.
Lima duplicata.
Limopsis oolithicus.
Macrodon Hirsonensis.
Myacites abductus.
„ calceiformis.
„ securiformis.
Mytilus furcatus.
„ imbricatus,
„ Lonsdalei.
„ Sowerbyanus.
Ostrea costata.
„ Sowerbyi.
Pecten annulatus.
„ arcuatus.
„ vagans.
Pholadomya Heraulti.
„ socialis.
Pholas costellata.
Pteroperna costatula.
Quenstedtia oblita.
Trigonia Moretoni.
„ V—costata (?)
Unicardium impressum.
Terebratula globata.
„ maxillata.
„ perovalis.
Rhynchonella concinna.
Acrosalenia.

We now pass, on an embankment, the road leading from Rollright to Over Norton. A little further on, the line is cut through the northern slope of a hill. Great Oolite is here seen dipping strongly to N. by E., and rising on the banks at an angle of 5° to W.; the far greater part of it running out before reaching the next, or "Langton," bridge, on the Long Compton road, distant 330 yards from the commencement of the cutting; whilst the Inferior Oolite comes in at the bottom, below a black clay with oysters and *Pecten vagans*, apparently the "Upper Estuarine." The Great Oolite limestones are separated by clayey oyster-bands of variable thickness. Beyond the bridge, thick-bedded limestones of the Inferior Oolite rise successively above the surface, dipping 14° to N.W., and curving downwards upon the banks. Beneath the black estuarine clay appears a layer of reddish-brown sand, which, on careful examination, is seen to be continuous with a bed of soft, travertine-like sandy limestone, with casts of gasteropods, many of them having the look of *Paludinæ*, and vegetable remains. This limestone, which under the microscope has exactly the aspect of

weathered mortar, contains 36 per cent. of siliceous sand ferruginous clay, so that its conversion into red sand by solu- ι of the calcic carbonate is easily understood. Professor Morris s me that a similar bed occurs in the Lincolnshire Limestone. top of it is a hard, coarse, crystalline limestone, made up of *'ed* fragments of shells, urchin spines and plates, oolite and eous grains, cemented by calcite. This exactly resembles the terial of the so-called "Druidical" (but, doubtless, sepulchral) ollright Stones," which stand upon elevated ground on the ndary of Oxfordshire and Warwickshire, a mile and a-half W. of Langton Bridge. Below, are thick beds of limestone, ne sandy, others oolitic, or compact and somewhat slaty; all se conditions sometimes occurring, and by no means regularly, the same block. The joints are wide, and filled with sand. lse bedding is not unfrequent. Similar beds are quarried just ow Great Rollright.

The following complete section was measured, with the kind operation of Mr. E. B. Tawney, F.G.S., of the Bristol Museum, the 22nd of July last:—

ECTION OF GREAT AND INFERIOR OOLITE, AT LANGTON BRIDGE CUTTING.

		Ft.	In.
1.	Limestones with partings of grey Clay	10	6
2.	Ditto	12	0
3.	Ditto	6	6
4.	Ditto	9	0
5.	Coarse slaty Limestone	5	0
6.	Clay with oysters	1	7
7.	Slaty sandy Limestone	1	7
8.	Limestone	1	3
9.	Grey, sandy, laminated Clay	1	3
10.	Rubbly Limestone	3	10
11.	Limestone, oolitic	10	0
12.	Rubbly Limestone, with many *Cypricardia Bathonica*, and *Ostrea Sowerbyi*	2	6
13.	Pale grey Clay, with *Ostrea Sowerbyi* and *Rhynchonella concinna*	2	0
14.	Limestone, slaty, with *Rhyn. concinna*	1	8
15.	Limestone	4	0
16.	Black Clay, with oysters, &c	6	9
17.	Reddish Sand, or travertine-like Limestone ...	5	6
18.	Brownish sandy Limestone	7	6
19.	Compact Limestone, rather sandy	3	9
20.	Reddish-brown Clay	0	1¼
21.	Light-brown compact Limestone, slightly oolitic ...	2	4
		98	2¼

The upper part of the section (1, 2, 3, 4) is too much obscured by *débris* for the separate measurement of the beds. Beds (1-12) belong to the Great Oolite; (13) presumably to the Upper Estuarine; the remainder to the Inferior Oolite. Possibly, the "Paludina" bed may represent the Lincolnshire Limestone, or the Stonesfield Slate. I have found no distinct evidence of the occurrence of the "Clypeus Grit," of which we get some traces at Chipping Norton. The thickness of the Great Oolite in this fine section exceeds 70 feet; and to this is to be added at least the two upper beds of the Rollright Bridge section, given before. The late Professor Phillips estimated it at 60 feet for Oxfordshire; for the neighbourhood of Banbury I have taken it, but on very uncertain data, at 50 feet. From this spot the line runs in a considerable curve along lower ground mostly occupied by the *Capricornus* clays, skirting the outcrops of the *Margaritatus* and *Spinatus* zones, as far as Salford Hill, north of Chipping Norton. This hill, according to the Ordnance Survey, is 728 feet above sea level; and its summit is more than 150 feet above the low ground at its base. *Capricornus* beds are at bottom, surmounted in order by the *Margaritatus* and *Spinatus* zones of the Middle Lias, the Upper Lias, and the Inferior Oolite; the "Clypeus Grit" of the *Parkinsoni* or upper zone of the latter occupying the summit, and its "wash" extending to a considerable distance over the flanks, hiding a good deal of the outcrop of the Upper Lias. This "wash" also covers the outcrop of the *Murchisonæ* zone, if it is present, as it ought to be, for it is well developed in the hill above the town of Chipping Norton, although at Charlbury, six miles S.E., it is no longer found, "Clypeus Grit," with *Ammonites Parkinsoni* being only present.

An embankment of no considerable height, leads to a cutting in the hill that forms the approach to the tunnel. Here we at once notice the large blocks of bluish nodular marlstone, characteristic of the *Margaritatus* zone; and above them reddish-brown lumps and rubble belonging to the *Spinatus* zone, to which the term "*Marlstone*" is now ordinarily restricted. Unfortunately, for the sake of keeping up the banks, which are unusually steep, and often very wet, grasses have been sown upon them, so that they cannot now be observed so readily as a year ago. Above the mouth of the tunnel a few feet of black Upper Lias clay is seen, but without any of the bands of concretionary argillaceous limestone usually met with at the base, as at Bloxham. From a plan of the tunnel,

for which I am much indebted to the courtesy of J. A. Moseley, Esq., the resident engineer, I gather the thickness of this formation to be from 30 to 36 feet.

The rows of blocks of the Middle Lias, though somewhat irregular from minor displacements, are upon the whole nearly horizontal; but near the mouth of the tunnel they dip perceptibly. Observations in the tunnel itself, for which I am also indebted to Mr. Moseley, show that the beds roll over within the hill, so that in the middle the lower row of stones is above the roof, and the roadway is excavated in the *Capricornus* clays below. From these were brought up the fine specimens of *Ammonites Capricornus*, *A. Davoei*, *A. Henleyi* and *A. fimbriatus*, and other species.

The base of the tunnel is 108 feet below the summit; the shafts by which it is worked are 70 feet deep. It is about three-quarters of a mile in length.

SECTION AT ENTRANCE OF TUNNEL.

			Ft.	In.
	1.	Upper Lias Clay	10	0
	2.	Brown sandy Marlstone (*Spinatus*) ...	11	0
	3.	Shale	5	6
Margaritatus Zone.	4.	Bluish-grey siliceous Marlstone (with a band of *Serpulæ* in middle)	2	0
	5.	Shale	4	0
	6.	Blue siliceous Marlstone	2	6
	7.	Blue *Capricornus* Shales.		

In the cutting, the marlstones of the *Spinatus* zone are much corroded and decayed from the great quantity of water draining through them from the gathering ground above. Some of the harder parts stand out from the face like concretionary blocks; but even these have lost a portion of their lime, and are more or less soft and sandy. Little has been done with them, and it is hardly worth while to give a list of the few common fossils noticed. The harder stones of the underlying zone have been much better preserved, and their unusually abundant and interesting fossils are in wonderfully fine condition—their tests, even in the case of delicate shells, and their external ligaments, being generally perfect. *Cardium truncatum* and *Cypricardia intermedia*, Moore (the typical *C. cucullata*, is very rare), of large size, occur in masses, and in a condition rarely seen. *Macrodon liassinus* is plentiful, and equally fine. The abundance of *Anatinidæ* is worthy of notice, and with the drift wood and leaves of *Zamites*, points to the vicinity of land.

The upper band of this stone is greyish-blue, hard and somewhat

crystalline. In the middle is a seam with abundance of *Ditrypa circinata*. The fossils noticed *in situ* upon one occasion were—

Ammonites Algovianus,	Avicula papyria,
" margaritatus.	Cypricardia intermedia.
Belemnites elongatus.	Gryphæa gigantea.
Chemnitzia cithara.	Macrodon liassinus.
" foveolata.	Modiola scalprum.
Dentalium *sp.*	Pecten æquivalvis.
Astarte, small, 2 or 3 species.	Pleuromya ovata.
Avicula cygnipes.	Hemipedina (spines).
" inæquivalvis.	Pentacrinus *sp.*
" Münsteri.	

The lower stone, at the northern cutting, 2½ feet, but at the southern, said to be 4½ feet thick, is of a darker blue, and more sandy and marly. Fossils observed *in situ* were—

Belemnites elongatus.	Ostrea.
Chemnitzia Blainvillii.	Pecten liassinus.
Cypricardia intermedia.	" strionatis.
Gryphæa gigantea.	Pleuromya rostrata.
Leda Zieteni.	Rhynchonella lineata.
Limea acuticosta.	Crustacean.
Macrodon liassinus.	Zamites.
Modiola scalprum.	Drift wood.

In sandy nests, in a few of the quarried blocks, but of which bed is not clear, many beautiful little gasteropods and bivalves have been found; some of them not yet identified with described species.

The abundance and fine condition of the fossils of these beds have drawn the attention of collectors to the spot, and several good collections have been made, amongst which I may especially mention those of Mr. T. J. Slatter, of Redditch, and of Mr. James Windoes of Chipping Norton. I mention these gentlemen, not only on account of the surpassing excellence of their collections from this spot, but also for their extreme liberality and kindness in allowing me to make use of them in the preparation of the accompanying list. Mr. Slatter's extensive and accurate knowledge of Lias fossils is well known, and the names to which [S] is attached, are, I am satisfied, deserving of all confidence. Of the latter gentleman I shall have occasion to speak hereafter.

FOSSILS FROM THE CAPRICORNUS AND MARGARITATUS ZONES, CHIPPING NORTON TUNNEL.

[*C.*] *Capricornus* zone. [*S.*] names of species contributed by Mr. Slatter alone.

Fish teeth (Pachycormus?) and vertebræ.	Ammonites Algovianus, Oppel.
	" capricornus, Schlot (*C.*)

Ammonites Davoei, Sow. (*C.*)
„ fimbriatus, Sow. (*C.*)
„ Henleyi, Sow.*
„ margaritatus, Mont.
„ nudus.
Belemnites apicicurvatus Blainv. (*C*).
„ breviformis, Voltz.
„ brevis, Dum. (*S.*)
„ clavatus, Blainv. (*C.*)
„ elongatus, Sow.
Nautilus, *sp.*
Actæonina Ilminsterensis, Moore.
„ marginata, Simp.
Cerithium, *cf.* acicula (*S.*)
„ *sp.* (S.)
Chemnitzia Blainvillii. Münst.
„ cithara.
„ citharella (?) Tate.
„ crassicosta (*S.*)
„ foveolata, Tate.
„ nuda (?) Münst.
Cryptænia complanata, Desl.
„ expansa, Sow.
Dentalium elongatum, Münst.
„ giganteum, Phill.
„ gracile, Moore (*S.*)
„ minimum, Str.
Discohelix aratus, Tate.
„ Wrightii, Tate.
Eucyclus imbricatus, Sow.
„ Julia, D'Orb. (*S.*)
„ undulatus, Ph.
Littorina biornata, Tate.
„ Clevelandica (?) Tate.
Orthostoma fontis, Dum. (*S.*)
Pleurotomaria similis, Sow.
Rostellaria, *sp.* (*S.*)
Trochus mammillaris, Moore (*S.*)
Turbo cyclostoma, Münst.
„ Dunkeri (?)
Anatina myacina, Tate. (*S.*)
Anomia numismalis, Q. & sp. (*S.*
Arcomya concinna (?) Tate.
„ elongata, Röm.
„ hispida (?) Simps.
„ longa, Buv.
Astarte consobrina. C. & D. (*C.*)
„ Lugdunensis.
„ 4 or 5 minute species.
Avicula calva, Schlot.
„ cygnipes, Y. & B.
„ inæquivalvis, Sow.
„ „ v. interlævigata
„ „ v. acuticosta.
„ Fortunata, Dum. (*S.*)
„ Münsteri, Goldf.
„ papyria, Q.
Cardinia antiqua, Phill.
„ hybrida, Stuch.
„ crassissima, Sow. (*S.*)
„ lævis, Y. & B. (*S.*)
Cardita liassina, Ph.
„ multicosta, Moore.
Cardium truncatum, Sow,
„ *sp.*
Cypricardia cucullata, Münst.
„ intermedia, Moore.
„ pellucida, Moore. (*S.*)
Ceromya petricosa, Simp.
Cucullæa Münsteri, Ziet.
„ ovum, Q. (?) (*S.*)
„ nitidissima, Tate (*S.*)
Gervillia erosa, Simps.
„ lævis, Buck. (*S.*)
Goniomya hybrida, Münst.
Gresslya intermedia, Simp.
„ punctata, Simp.
„ lunuluta, Tate.
„ Seebachii, Brauns (*S.*)
Gryphæa gigantea, Sow.
Hippopodium ponderosum, Sow.
Harpax lævigatus, Dum. (*S.*)
Inoceramus ventricosus, Sow. (*C.*)
Leda Zieteni, Brauns.
„ graphica, Tate.
„ Galatea, D'Orb.
„ minor, Simp.
Limea acuticosta, Goldf.
Lima Hermanni, Voltz.
Lucina pumila, Münst. (*S.*)
Macrodon Buckmani, Rich.
„ liassinus.
„ intermedius (?) Simp.

* Mr. Windoes has a portion belonging to one 18 in. diameter.

Macrodon pulchellus, Slatter (*S.*)
Modiola numismalis, Oppel. (*C.*)
„ scalprum, Sow.
Nucula cordata, Goldf.
„ navis, Piette. (*S.*)
Opis Ferryi, Dum. (*S.*)
Ostrea irregularis, Goldf. (*S.*)
„ sportella (?) Dum. (*S.*)
Pholadomya ambigua, Sow.
„ „ v. recurva. (*S.*)
„ „ v. Voltzii. (*S.*)
„ Simpsoni, Y. & B. (*S.*)
Pinna folium, Y. & B. (very large)
Pecten acuticostatus, Lam. (*S.*)
„ æquivalvis. Sow.
„ calvus (?) Goldf.
„ liassinus, Röm.
„ frontalis, Dum. (*S.*)
„ priscus, Schl.
„ strionatis, Q.
„ textorius, Schl.
„ Rollei, Dum. (*S.*)
Pleuromya costata, Y. & B.
„ granata, Simp.
„ Jauberti, Dum. (?)
„ mundula (?) Tate.
„ ovata, Röm (?)
Plicatula spinosa, Sow.
Tellina fabalis, Tate.
„ gracilis, Dum.
Unicardium cardioides, Ph. (*C.*)
„ globosum Moore (?) (*S.*)
„ varicosum. (*S.*)
Lingula sacculus, Ch. and D.
Rhynchonella lineata. Y. & B.
„ rimosa, Y. & B.
Spiriferina oxygona, Desl.
Pseudoglyphæa Etalloni (?) Oppel
Crustacean, *sp.*
Bairdea dispersa, Blake (*S.*)
„ liassica, Brodie.
Cytherella crepidula, Blake. (*S.*)
Polycope, *sp.* (Mr. E. Walford.)
Ditrypa capitata, Ph.
Ditrypa circinata, Tate.
„ etalensis, Dum.
„ quinquesulcata, Münst. (*S.*)
Serpula pentagonalis, on Pentacrinites.
„ plicatilis, Goldf.
Cidaris Edwardsii, Wright.
Hemipedina spines
Pentacrinus scalaris.
„ *sp.*
Cristellaria crepidula, F. & M. (*S.*)
„ Bronnii. Röm. (*S.*)
„ pauperata T. P. (*S.*)
„ recta, D'Orb. (*S.*)
„ rotulata, Lam. (*S.*)
„ rustica, Terq.
„ varians, Röm. (*S.*)
Dentalina funiculosa, Terq. (*S.*)
„ matutina, Terq.
Flabellina radiata. (*S.*)
„ rugosa, D'Orb. (S.)
Frondicularia Terquemi, D'Orb. (*S.*)
„ sulcata, Röm. (S.)
Glandulina humilis, Röm. (*S.*)
Lagena elongata (?) Ehr. (*S.*)
Lingulina tenera, Röm. (S.)
Marginulina dichotoma.
„ v. Burgundiæ. (*S.*).
„ inæquistriata. (*S.*)
„ picta, Terq. (*S.*)
„ prima.
„ raphanus. L. (*S.*)
Nodosaria humilis, Terq.
„ prima, Terq.
„ raphanistrum, L.
„ raphanus, L.
Oolina pentagona (?) (*S.*)
Polymorphina simplex Terq. (?) (*S.*)
Planularia.
Trochammina gordialis.
Zamites. (leaf).
Drift wood.

About Chipping Norton a great quantity of Dinosaurian re-

ıains have been found in the Inferior Oolite, many of them be-ınging to Cetiosaurus. I have seen by the road-side a heap of ;ones largely composed of these bones.

Looking back from the lofty hill which has been the western mit of our excursion, upon the Oolitic tract over which we have ıtely travelled, I may remind you that we have had the oppor-ınity of studying, more or less completely, all the formations from ıe *Capricornus* zone of the Middle Lias to the Cornbrash of the ıower Oolites; and most of them have presented interesting, and ı some cases, unexpected features. We have examined them very astily, and have left very much for future observers and collectors › complete. The Inferior Oolite, in particular, is deserving of the ıost careful study. Its thickness, although far below that in łloucestershire and elsewhere, is considerably greater than was ıought probable; and it is not unlikely that a critical examination ıay prove that other zones may be present than those previously ɔticed in these parts.

Having now brought my very imperfect description to a con-usion, I have only again to express my obligations to those gen-emen whom I have already named, as well as others, without whose ısistance this paper would have been still more unworthy of your ıtention. To Mr. Windoes, of Chipping Norton, I am especially ıdebted. Distance from the field, and other occupations, have ːevented me from paying that attention to the actual sections hich is so necessary for a trustworthy account of them. Mr. Win-ɔes has always been ready and zealous in assisting me. Not only as he at once communicated to me the very numerous and rare ›ssils which he has extracted from every bed, and without which ıy lists would often have been meagre ; but he has always been eady, in the little leisure he could snatch from his daily avoca-ıons, to visit any spot about which I might need information, and ıost intelligently explore and observe it. Should the Association e disposed to visit the sections which I have endeavoured to des-ribe, I know that he would gladly give them all the help in his ower.

EXCURSION TO DERBYSHIRE.

MONDAY, JULY 22ND, 1877, AND FIVE FOLLOWING DAYS.

Directors—REV. J. MAGENS MELLO, M.A., F.G.S., and ROOKE PENNINGTON, Esq., LL.B., F.G.S.

(*Report by the* REV. J. MAGENS MELLO.)

A large party of the Members of the Association and a few friends arrived by the mid-day train at Clay Cross, where they were received by J. P. Jackson and C. Binns, Esqrs., and by the Rev. J. M. Mello, M.A., F.G.S. On arriving at the collieries of the Clay Cross Company, they were entertained at luncheon by the owners, after which they proceeded to inspect some of the coal-pits, in which the numerous and beautifully preserved fossil plants, ferns, lepidodendra, etc., and the mode of occurrence of the coal, and the manner in which it was worked, created much interest. Attention was also called to the presence of an enormous sub-angular mass of Ganister rock in the clay, exposed close by in the receptacle that was being made for a new gasometer. At the offices of the Company a large series of beautiful fossils from the coal-shales were most kindly placed at the disposal of the visitors. Subsequently the party drove to Chesterfield, *viâ* Milltown and Ashover, examining on the way the extensive lead mines at the former place, and also during the journey the various members of the Carboniferous or Mountain Limestone, as it is usually called in Derbyshire, the Yoredale Series and the Millstone Grit, as they successively cropped out. The fine quarries in the "Rough Rock" or "First Grit," at Stannedge, attracted considerable attention, the rock here being very massive, and magnificently jointed.

On TUESDAY morning the Association left Chesterfield in carriages, and drove to Creswell, where the important bone caves lately explored and described by the Rev. J. M. Mello and Profs. G. Busk and W. Boyd Dawkins, at the Geological Society of London, were visited. The Rev. J. M. Mello explained the manner in which the various remains had occurred in the caves, and called attention to the great geological importance of the discoveries made there, which in some respects are unique; a distinct succession of beds containing evidences of the progress in civilization of Palæolithic man having been observed in these caves, a succession represented with such distinctness in no other single cavern. An en-

graved bone was also found here, the first discovery of the sort in Great Britain, and which correlates the old Derbyshire caves with those of France and Switzerland; another important discovery which had been made at Creswell was a canine tooth of the strange sabre-toothed Machairodus. Several teeth of various animals and a few flint implements were found by members of the party among the *débris*. In the afternoon, after returning to Chesterfield, the geologists drove to Bakewell through Chatsworth Park.

On WEDNESDAY the party left Bakewell to visit Miller's Dale and Buxton. At Miller's Dale the Toadstone and lead mining operations were examined, and specimens of minerals obtained, galena, calamine, and calcite being the principal ones. In Tideswell Dale a curious bed of columnar clay was an object of interest; this, which was described in the "Quarterly Journal of the Geological Society," for February, 1871, and figured there, appears to be a volcanic mud, baked into its present prismatic form by the heat of the overlying igneous rock, which here was seen to consist of an almost basaltic rock, a very dense and fine-grained dolerite, containing numerous concretionary balls, like volcanic bombs in shape. Dr. Maybury advocated the opinion that the prismatic clay was really the result of the decomposition of the Toadstone, and not the result of mud subjected to its heat and pressure only. The Rev. J. M. Mello considered that analogy rather favoured the latter view, inasmuch as such red clays are frequently found interbedded with dolerites, and have been altered by their heat in some cases; also that the surface of the toadstone resting on the red clay is sharply defined from it, and is vesicular in character, it would also be difficult to account for the presence of the alumina in such abundance, it not being the prevailing mineral in the dolerite; and lastly it was often found that the clay in brickyards presented a precisely similar appearance to that in question.

From Miller's Dale, Chee Tor, a fine cliff of Carboniferous Limestone, was visited, and the gorge-like character of this part of the dale well seen. Some of the party walked from here to Buxton, where they were joined by the remainder, who preferred going by train, after previously disposing of some sandwiches and tea, which had been provided by Dr. Foulerton in a most cunningly contrived apparatus. Poole's Hole, and the extensive Limestone quarries were the objects of interest at Buxton. The cavern called Poole's Hole is too well known to need description; the museum attached

to it contains a most nondescript assortment of curiosities, togethe with a few Romano-British antiquities, and bones derived from th cavern itself, and it was felt to be a great pity that this cavern ha not been systematically explored before its floor had been so muc disturbed. On the way to the quarries the remarkable calcination o an extensive portion of the hillside above Poole's Hole was noticed and as no traces of lime-kilns of modern construction were any where visible, and the huge calcined mounds were in many place overgrown with trees and shrubs, it was suggested, in the absenc of any other information, that the Romans may have burnt lim there. The quarries were much admired, and the interesting effect of atmospheric denudation were well seen on the exposed uppe surface of some of the beds.

On THURSDAY morning the party left Bakewell by train fo Chapel-en-le-Frith, where R. Pennington, Esq., F.G.S., joine the party, and all set off in carriages to Castleton, examining *e route* the outcrop of the Yoredale Grits, and the Swallow Hole along the line of junction between the Yoredale Shales and th Carboniferous Limestone. At Eldon Hill a pause was made, an the barrow on the summit was looked at. It had been opened som time previously by Mr. Pennington and Mr. John Tym, the well known mineralogist at Castleton, and some remains of interes obtained, which were described by Mr. Pennington. At Eldo Hole, which was close at hand, he also gave an account of hi somewhat adventurous descent into it in company with Mr. Tym and he described it as an almost vertical fissure, expanding at th bottom into a fine cavern. Some amusement was afforded on th ascent of Eldon Hill, by the illustration afforded by some of ou friends of the doctrine of the "survival of the fittest;" the effor was almost too great for one or two, who made their appearance o the top as the rest began the descent. On the way to Castleto another pause was made at the Windy Knoll quarry, when Mr Pennington gave a short sketch of his exploration of a fissure i Swallow Hole, in which a large assemblage of Bison, Reindee Bear and Wolf bones were found. It had apparently been a drink ing place, where these animals, in the course of their annual migra tions across the country had got engulphed. At this quarry som of the party entered a small "swallow-hole" or cave, which pierce the hill close by; and others secured specimens of *Elaterite* o elastic bitumen, a rare mineral, which occurs here in some abun-

dance, and also of "Blue John," and picked up many small fragments of the bones of some of the animals previously mentioned.

Leaving Windy Knoll, the well-known Blue John Mine was entered, and on the slopes of Trecliff some of the party, who had to walk in consequence of an accident to a wheel, were able to glance at the Odin mine, and to obtain some good Carboniferous Limestone fossils. At Castleton a capital luncheon, given to the Members of the Association and their friends by Mr Pennington, was done justice to, after which the admirably-arranged Castleton Museum was visited, Mr. Pennington explaining its contents. The geological collection here was found to be most instructive, containing typical fossils from all the formations, and including a remarkably fine series of bones and implements, illustrative of the lately finished explorations of Creswell Caves and Windy Knoll, as well as specimens from other localities. This little Museum quite puts to shame many a far more pretentious collection. On leaving the Museum, the entrance to the great Peak Cavern was visited, and then the party went to the Speedwell mine, which was beautifully illuminated by Mr. Tym, who was indefatigable in his efforts on behalf of his visitors.

On FRIDAY some of the hardest work during the excursion was done. The majority of those present walked by Back Tor, Edale and Grindsbrook Clough, over Kinderscout to the Snake Inn. The weather, which at first looked threatening, proved delightful, and the magnificent scenery, and instructive geological phenomena, rendered the walk over this wildest part of Derbyshire most enjoyable. The track followed led from the Carboniferous Limestone border at Castleton, over the Yoredale Shales of the valley, these, as the ascent was made up the slopes of Back Tor, were seen to be overlaid by the Yordale Sandstones and Grits, which often form fine escarpments, owing to the slips which take place through the denudation of the Shales; such slips were well seen on the flanks of Mam Tor, the whole hillside having fallen away, and carried with it part of a British Camp, traces of which were seen on the summit. The Yoredale Shales were again crossed in Edale, where they are covered by a very considerable thickness of coarse river drift. Passing up Grindsbrook, and ascending Kinderscout, the Yoredale Grits were seen to be capped by the lowest member of the Millstone Grit series, the Kinderscout Grit, here a conglomerate containing numerous rounded pebbles of white quartz. The

it is almost impossible that their remains should be found,* whilst the existence of other forms may not readily be detected except as impressions.† Again some forms of life have not yet been observed, owing to their minuteness, yet from the known habits of other existing animals as to their food we may infer that such minute forms might have existed. Secondly,—the relations of the extinct forms to those that now live upon the globe, from which it appears that the present great divisions or types of the organic world include also all those that are found in a fossil state; so that, broadly speaking, the scheme of creation, past and present, becomes one uniform whole. Thirdly,—the deductions that may be drawn from the habits of existing forms as to the probable conditions under which former animals and plants lived, so that we may understand more clearly, and reason more safely, respecting the varied conditions by which the different sedimentary rocks containing their remains were accumulated.‡ Again, the study of these remains shows to some extent the order of succession of life upon the globe, and how far from past times to the present there has been any progression; thus enabling us to consider the relation of the animals and plants which now live upon the surface of the earth to those which have existed in former times.

Geographical Provinces.

From the various admirable memoirs and papers which have of late years been published upon the geographical distribution of animals, we learn that the present surface of the globe has been divided into a series of Natural History Provinces based upon the principle that certain forms of animals and plants are peculiar to each of these provinces. According to the different views of the naturalists who have studied the subject, they have been divided

* Dr. S. Woodward states there are about 600 species of soft or naked Mollusca. "Manual of Mollusca, p. 348."

† M. D'Orbigny terms some of these, physiological impressions. "Cours Elémentaire de Paléontologie," p. 27.

‡ Not only do we find the Miocene beetles differentiated and adapted to all the habits of life which their Oolitic predecessors had already possessed, but for the first time we come across true *flower-haunting* beetles, belonging to groups actually specialized in our own day to particular genera of flowers. So striking is this that Professor Heer infers the existence of such flowers (*although they have not as yet been found*) during the Miocene epoch. J. E. Taylor, "Popular Science Review," Jan., 1878, p. 44.

into a greater or less number. Thus Professsr Huxley* makes four main divisional provinces—(1), Arctogæa, which includes a very considerable portion of the northern hemisphere, and three other divisions, North America, Africa, and India; (2), New Zealand; (3), Australasia, and (4), Austro-Columbia, including South America, and a portion of North America, North of Mexico. Mr. Wallace has divided them into six provinces, respectively named according to the regions so circumscribed by him—Palæarctic, Ethiopian, Oriental, Nearctic, Neotropical, Australian.† According to Dr. Sclater, there are nine principal, zoo-geographical provinces (with minor sub-regions) dependent on his views of the restricted distribution of animals.‡ Mr. Griesbach§ divides the surface of the globe into 24 natural regions of vegetation, each of which is supposed to have been a centre of creation where the several characteristic floras took their origin.

Taking the distribution of Mollusca, we find that Dr. S. Woodward increases the number, making 27 land regions—that is to say, 27 regions based entirely upon the land and freshwater shells of those respective areas—and 18 marine provinces based upon the peculiar distribution of marine forms.‖

DISTRIBUTION OF FOSSILS.

The present distribution of animals and plants upon the globe is one of extreme interest, both to the Biologist and to the Geologist, inasmuch as it bears upon the origin of the animals and plants of those divisional provinces, and the question is suggested why are they now so specially localised, and whether as we recede back in time there were equally good divisional provinces? It is to

* On the Alectoromorphæ, &c., Proc. Zool. Soc., 1868, p. 316. "Thus, if we consider the distribution of the Alectoromorphæ alone, the whole surface of the globe must be primarily sub-divided into two principal areas—a northern and a southern. And I think it is not difficult to show, from other considerations, that these are really the most important divisions which can be established for the geographical distribution of both Birds and Mammals." See also Ann. Address Geol. Soc., 1870.

† On the Comparative Antiquity of Continents, Proc. Roy. Geogr. Soc., Vol. 21, 1877.

‡

Palæarctic, Ethiopian, Lemurian, Indian, Nearctic	Arctogæa	Neotropical, Antillean	Dendrogæa
		Australian	Antarctogæa
		Pacific	Ornithogæa

"British Assoc. Report," 1875; Sections p. 86.

§ Die Vegetation der Erde nach ihrer Climatischen Anordnurg, 1872. Translated into French by M. Tchihatchef.

‖ "Manual of Mollusca," pp. 349-381

assist us in replying to this enquiry that I wish to recall attention to the facts relating to the distribution of life upon the globe in past times. From the knowledge which has been derived by the researches of various geologists during many years past, we are conversant with the fact that in each of these so-called divisional provinces—each of these separate areas—there has been a succession more or less of distinct deposits, as well as of animal life, from the earliest times observed in each of them up to the present day.* The question naturally arises, what relation does this succession of life, and of formations found in these respective provinces bear to each other? Were they in former times as dissimilar as they are at the present day, or were they more or less uniform? This can only be successfully answered by a careful study of the nature of the different rocks and of the organic remains of these respective areas, from which it appears that there is not only an apparent similarity of succession (that is probably not quite synchronous but homotaxial), but that a great number of forms are to some extent representative, and in some cases identical.† Did these similar forms, occurring in the same apparent relative position, originate in those respective areas, or did they not? Mr. Wallace, in speaking of land-areas, says—"As the theory of evolution does not admit the independent development of the same group in two disconnected regions to be possible, we are forced to conclude that these animals have migrated from one continent to another."‡

* Conybeare remarked in 1822, "It is to be regretted that we have as yet no means of ascertaining whether a similar succession of Secondary beds takes place in very distant countries (America for instance), and whether these are characterized by similar families of organic remains. As the recent animals of these countries are widely different, one would naturally suppose the fossils would be different also; yet in some instances we have reason to believe that this, in the earlier Secondary strata at least, is not the case," &c. "Outlines of Geology, Introduction," p. xiii. Note.

† Scarcely any palæontological discovery is more striking than the fact that the forms of life change almost simultaneously throughout the world. Thus our European Chalk formation can be recognised in many distant parts of the world, under the most different climates, where not a fragment of the mineral chalk itself can be found; namely, in North America, in equatorial South America, in Tierra del Fuego, at the Cape of Good Hope, and in the Peninsula of India. C. Darwin "On the Origin of Species," p. 349.

‡ On the Comparative Antiquity of Continents, Proc. Roy. Geogr. Soc., Vol., 21. "Thus cats, deer, mastodons, true horses, porcupines, and beavers existed in Europe long before they appeared in America. Camels and, perhaps, ancestral horses, on the other hand, were more abundant and more ancient in America, and may have migrated thence into Northern Asia." See also Professor Marsh, "Succession of Vertebrate Life in America," p. 50.

With regard to the distribution of similar fossils over wide and at present disconnected regions of the globe, a few facts may be stated.

M. Barrande and other European and American palæontologists show that many species of Crustacea and Mollusca are common to the Silurian rocks of Europe aud America.*

Professor McCoy states that certain species of Graptolites, found in the Lower Silurian rocks in the Victoria district of Australia, occur in strata of presumed similar age in Sweden, Bohemia, United States, Quebec, and in North Wales, and that the other conditions are somewhat similar, for these graptolites occur in slaty rocks in Australia and Wales, and in both cases these rocks are traversed by quartz veins containing gold.†

Mr. Lapworth has arrived at similar conclusions with regard to the range of the Graptolites: "The Graptolithina of the Lower or Glenkiln division are those of the highest Llandeilo Flags of Wales, the corresponding Middle *Dicranograptus*-schists of Sweden, and the Norman's Kiln shales that *underlie* the Trenton (Bala) Limestone of New York. The Hartfell species occur in the Bala beds of Conway, &c., the higher *Dicranograptus*-schists of Sweden, and the Utica and Lorraine shales that *overlie* the Trenton Limestone. Those of the Birkhill shales agree almost species for species with the fossils of the Coniston Mudstone of Cumberland, the Kiesel Schiefer of Thuringia, and the Lobiferous beds of Sweden, which lie at the summit of the Lower Silurians of their respective countries."‡

In the Upper Silurian, Devonian, and the Carboniferous rocks the same fossils are found in widely disconnected areas.

In the higher Silurian rocks of Australia, supposed to represent the Ludlow and Llandovery deposits, there are many species, according to Professor De Koninck, common to the European Silurian—Corals, 18; Brachiopods, 14; Lamellibranchs, 1; Ptero-

* Bigsby, "Thesaurus Siluricus," p. 29. D. Sharpe, Quart. Journ. Geol. Soc., Vol. 6. Miller, "American Palæozoic Fossils," 1877.

† Professor McCoy says—"Having, shortly before coming to Victoria, knocked out with my hammer, from the slate rocks of the Welsh old Roman gold mines, at Gogofau, near Llanpump-saint, exactly the same species of Graptolites which I found to be the most common in our gold-field slates in this colony; showing that the Romans had obtained their gold from quartz veins in slates in Wales of exactly the same geological age as our Australian formations." "Palæontology of Victoria," 1874, Decade 1, p. 5.

‡ Proc. Geol. Soc., No. 341, Nov., 1877.

pods, 2; Crustacea, 8; and in higher beds referred to the Devonian are species found in the Devonian and Carboniferous of Europe—Corals, 14; Brachiopods, 2; Lamellibranchs, 2; Gasteropoda, 6. Of the 249 species from the Carboniferous rocks of New South Wales, 81 are considered to be identical with those from the same formation in Europe; of these, 22 are common to all three divisions of the Carboniferous Limestone, and 36 belong exclusively to the upper division, from which M. de Koninck infers that it is the upper series which is mostly represented in New South Wales.*

From the Carboniferous Limestone of Bolivia, Franz Joula mentions some species of Brachiopoda characteristic of the same formation in Europe, as *Spir. striata*, *Spir. octoplicata*, *Rhynchonella pleurodon*, *Orthis resupinata*, *Productus cora, and Prod. semireticulatus.* The latter form, with other European Carboniferous species, have been described by Professor Beyrich as occurring in the Island of Timor.

In other and newer formations similar facts as to the wide distribution of species have been noticed, as in the Triassic, Jurassic, Cretaceous and Tertiary deposits of widely separated areas.

Thus fossils characteristic of the Trias of Hallstadt, in Europe, have been observed by Dr. Hector in beds of similar position in New Zealand, as *Monotis salinaria*, *Halobia Lommelli.* These and other Triassic forms, showing their wide distribution, have been noticed in Nevada, California, Arabia, New Caledonia, Siberia, Thibet, and Timor. (Marcou, p. 126.)

Professor Duncan says—"The Upper Trias in the Himalayas has a very European facies of the St. Cassian type, and contains *Halobia Lommelli*, *Ammonites floridus*, and *Orthoceras latiseptum*,† and four European Brachiopods."

The Middle and Upper Liassic and Oolitic faunas of distant localities are foreshadowed in the Upper Rhætics of the Himalaya, but the Jurassic formations of India also contain European species.‡ Mr. C. Moore§ has pointed out the identity of some Australian

* "Recherches sur les Fossiles Paléozoiques de la Nouvelle—Galles du Sud." Bruxelles, 1876—77.

† Annual Address, Geological Society, Feb., 1877, containing some suggestive remarks on the distribution of fossils and the bearings of Palæontology on evolution.

‡ Duncan, Presidential Address, Geol. Soc., Feb. 1877, p. 50; also "Abstract of the Geology of India," p. 41.

§ Quart. Journ. Geol. Soc., Vol. 26, p. 231.

species with those from the English and European Lias and Inferior Oolite.*

Don A. R. de Corbineau, in his "Palæontology of Chili" (Santiago, 1867), cites sundry species of Ammonites and of Brachiopoda from strata in the valley of Copiapo and adjoining districts, as identical with those occurring in the Jurassic rocks of Europe.

In the province of Coquimbo there are some fossils characteristic of European Cretaceous strata, and the Cretaceous rocks of India contain species identical with those from the White Chalk and Upper Greensand of Europe.†

The Coal Measures of America have many plants in common with those of Europe—some species occurring also in Eastern Siberia, Arctic Greenland Lat. 77°, also in the Brazilian and Australian coal fields. The striking resemblance of the Mesozoic coal floras with those of Europe, India and America has been long noticed, as well as the marked similarity of character of the flora of the Miocene period over a wide area, as in Greenland, North America, and Europe.

The *Producta semireticulata* is found in the Carboniferous rocks of Europe, America, Brazil, Bolivia, India, China and Australia. This wide distribution of the same species in the old Palæozoic seas is represented at the present time by another brachiopod, having a wide range, the *Crania ringens*, which, according to Mr. Davidson, is now living in the Mediterranean and in the seas of

* Vouloir qu'on ait les mémes formes d'êtres en Australie et en Europe à chaque époque géologique, est evidemment aller contre tous les principes de géographie physique et naturelle et contre tous les resultats acquis actuellement en géologie et en géographie. Sans donte, on cite quelques Brachiopodes et autres animaux inferieurs comme identiques en Europe et en Australie, mais leur contemporanéité ne s'ensuit nullement. Certaines formes d'êtres ont la vie extrêmement dure et robuste; rien ne peut anéantir, presque même en employant d'actifs moyens de destruction. Marcou, "Explication de la Carte Géologique de la Terre," p. 205.

† Professor E. Forbes remarked on the collection of fossils from Southern India, with regard to the distribution of animal life during the Cretaceous era—"It shows that during two successive stages of that era the climatal influence, as affecting marine animals, did not vary in intensity in the Indian, European and American regions, whilst the later of the two (Trinconopoly and Verdachellum stage) had specific relations with the seas of Europe, which are absent from the earlier (Pondicherry stage). The cause of this remarkable fact is not to be sought for in a more general distribution of animal life at one time than at another, but rather in some great change in the distribution of land and sea, and in a greater connection of the Indian and European seas during the epoch of the deposition of the Upper Greensand than during that of the Lower," Trans. Geol. Soc., Vol. 7. See also M. d'Archiac, Bull. Geol. Soc., France, Vol. 11, p. 202, &c.

Australia. The *Spirifera lineata* has also a wide distribution, but varies in size according to the localities (due to former conditions) where it is found.

Contemporary Faunas and Strata.

In the early history of Geology, Dr. W. Smith enunciated the law that strata were to be identified by their organic remains, and that strata containing similar fossils were of the same age. The later investigations of naturalists and geologists* seem to have considerably modified this doctrine, and if the law previously mentioned (p. 194) be true, then the strata in distant areas containing similar remains could not have been contemporaneous, while strata with dissimilar fossils may have been so.

De la Beche remarked that in the present comparatively advanced state of Geology, it behoves us carefully to weigh the conditions under which animal and vegetable life now exists, before we assume that a given deposit can or cannot be determined by its organic contents.†

As bearing on contemporaneous strata one or two facts respecting modern distribution may be noticed. M. D'Orbigny states that the east and west coasts of South America have a different molluscan fauna, with a very few similar species, and the genera are not equally distributed; of the 110 genera of Mollusca, 55 are common to both sides, the other 55 are differently distributed, 34 genera are peculiar to the Patagonian and Chilian coasts, and 21 to the Atlantic coast. The character of this fauna is further modified by the varying conditions to which it is subjected, such as depth, temperature, and currents, accounting for unequal distribution, and influencing the forms of life over the area; the cold currents from the south that are partially divided under Cape Horn (a portion passing through the Straits of Magellan), proceed upwards on the Pacific side to a far greater distance before they diverge than those which traverse the eastern side. Currents, therefore, are one means of distributing certain forms along coast lines; but there are other conditions in the nature of the old sea-beds. The genera which live upon the eastern coast of America are those which usually are to be found on sandy and muddy shores, that being for the most part the character of the Atlantic coast, while on the

* De la Beche, Woodward, Forbes, Huxley, Wallace.
† "Theoretical Researches," 1835, p. 224.

more rocky coast and the deeper seas of the western shore other genera are found which are adapted to that kind of habitat.*

The elevation of these contemporaneous sea-beds would show deposits with two distinct faunas having scarcely any species in common. Similar facts may be observed on the coasts of France, where the distribution of the genera of Mollusca are to some extent dependent on the physical surroundings, as in the Celtic, Lusitanian, and Mediterranean regions.†

Again deposits may be taking place on two distant shores, as those now occurring on the coast of North America and our own country. Dr. S. Woodward‡ states there are 70 species of Mollusca found on the coast of Massachusetts north of Cape Cod, and common to Northern Europe. If those shores were elevated, the examination of the two faunas might lead to the inference that the deposits had taken place, not only at the same time, but that they were probably also once continuous.§ As at present, so in past times, therefore, a series of forms might be living in two different areas contemporaneous with each other without being part of a continuous deposit, or, as suggested by De la Beche, equal circumstances existing in two different localities, the eggs of marine animals being transported from one to the other, by natural causes, deposits in the progress of formation in such localities may, though not continuous, contain somewhat similar organic remains.‖ On the other hand this coincidence may arise from some former coast-line now lost, which joined the two areas. A different amount of elevation of the two coast-lines (*i.e.*, America and England), producing an extinction of more species on one coast than on the other, might modify the comparison.

* D'Orbigny, "Cours Elémentaire," tome 1, p. 98; Woodward, "Manual of Mollusca," pp. 373, 4.

† D'Orbigny, "Cours Elémentaire," &c., p. 100; Delesse, "Lithologie du Fond des Mers," chap. 13. Lyell, "Elements of Geology," p. 104.

‡ "Manual of Mollusca," p. 358. Gould, "Invertebrata of Massachusetts," 1841.

§ With regard to a mixture of organic remains in contemporaneous deposits, Prof. E. Forbes shows that while vegetables of a sub-tropical character may be borne down by the Nile into the Mediterranean on one side, accompanying the remains of crocodiles and ichneumons, the Danube may transport parts of the vegetation of the Austrian Alps, with the relics of marmots and mountain salamanders, the marine remains mingled with these contemporaneous deposits retaining a common character. De la Beche, "Geological Observer," p. 146. Forbes, Rep. Brit. Assoc., Vol. xiii, 1843, p. 154.

‖ De la Beche "Theoretical Researches," p. 259.

With regard to deposits containing similar organic remains being contemporaneous, Sir H. De la Beche many years since* suggested that formations containing similar fossils were not necessarily of the same age, by showing that, presuming there is a coast-line with different zones of depth (1, 2, 3) extending seawards, each tenanted by slightly different living groups, there would occur three series of forms living in the same area, differing from each other; and, presuming that if this area was either depressed or elevated, two sets of conditions would arise. If the area were depressed gradually then, it will be perceived, the animal life living in zone No. 2 would creep over zone No. 1, while the animal life living in zone No. 1 would spread itself on the former sea shore; and as the depression went on, so in proportion would the animal life and deposits of No. 3 cover No. 2. On the other hand, if elevation took place the reverse of these conditions would arise, No. 1 overlying No. 2, and 2 over 3, and so on; and if the changes were comparatively gradual, there would be zones of life at different horizons containing similar forms, which would be deposited, not at the same time, but at different times.†

Recurrence of Species and Doctrine of Colonies.

In some districts are found a recurrence of similar species of fossils at two different horizons, separated by a great thickness of intervening strata, in which no trace of them occur; but these strata frequently contain a distinct assemblage of forms, thus indicating long periods of time, showing the caution to be exercised with regard to fossils as true chronological evidence.

In Bohemia, M. Barrande, describing his "Colonies," has shown that a series of Upper Silurian fossils occur intercalated in strata of Lower Silurian age, and which limited fauna does not appear again until after a long interval in the same area.‡ M. Barrande§ suggests that while the Lower Silurian fauna prevailed

* De la Beche "Theoretical Researches," p. 253.

† De la Beche, "Theoretical Researches,' 1834, p. 253.

‡ M. D'Orbigny doubts the theory of Colonies: "Puisque les colonies sont inconnues actuellement; mais qu'elle est un effet des oscillations du sol, qui a placé deux dépôts côtiers, separés par un dépôt sous-marin, à la suite d' affaisements et de sur-élévations alternatifs du sol." "Cours Elémentaire," tome 2., p. 309.

§ As bearing on the subject of Barrande's Colonies, Mr. C. Lapworth has sent the following extract from Dr. Linnarsson's paper, "On the Graptolite Schist of Kongslena, in Westrogothia":—"It has long been the general opinion that the Graptolites which characterise Barrande's Colonies and his Etage Fe. 1 had originally their home in the North of Europe, and that from

in Bohemia,* an Upper Silurian fauna already flourished, or co-existed, in some other more or less remote area, from which they either migrated or were drifted by currents into the then Lower Silurian sea, which they occupied for a certain time; but the conditions becoming unfavourable for their continued existence they did not return again into the same region until Upper Silurian times,† when they became the predominant fauna and were continuous in the two regions.

Professor Hughes applies the doctrine of "Colonies" in explanation of certain points observed in the Lake district. In the Winder Grit band, belonging to the Coniston Grits of Wenlock age, he describes a group of fossils having an "exclusively Ludlow facies," an entirely different fauna from that which usually occurs in the other fossiliferous portions of the Coniston Grits, both above and below. This band is separated by 7,000 feet of strata (with a totally different group of fossils) from the formation where the fossils which characterise it become the prevalent forms.‡

thence they made excursions into the Bohemian basin. In their earlier migrations they could not find complete footing there, and consequently formed a colony, which soon died out. Later—viz., at the time of the formation of Barrande's Etage Fe. 1—they established themselves in permanent occupation of the Bohemian basin. Formerly, when it was thought that the graptolites of the Upper Graptolite Schist of Sweden were co-existent with the trilobites of the subjacent Trinucleus Schist, and that their equivalent English Graptolite-bearing beds belonged to Llandeilo and Caradoc, such a view was very natural. Now, however, the better insight we have attained of the English and Swedish succession has robbed it of all its weight in this direction. There is no reason whatever for believing that the Graptolites which inhabited Barrande's Colonies emigrated from the Ocean of the N.W. Where they actually came from is, at least for the present, impossible to determine; but probably the Bohemian Colonies are *older* than all the Swedish and English beds in which the same fauna is found. Instead, therefore, of the emigration having taken place as believed hitherto (from Britain and Scandinavia to Bohemia), if we may judge from the facts now obtained, it ought rather to have taken place in the opposite direction."

* Barrande, "Defense des Colonies." Bull. Soc. Geol. de France, tomes xvii and xx. Murchison, "Siluria," 1867, pp. 375, 379.

† Prof. Bronn, after noticing the recurrence of Inferior Oolite species of Mollusca in the Great Oolite and Cornbrash of Gloucestershire, as bearing on the Colonies of Barrande, says: "Ainsi il n'y a pas de doute que le retour de conditions de vie identiques a par faire apparaitre une seconde fois dans certaines limites de temps des groupes ou colonies d'espèces animales, qui dans des circonstances moins favourables avaient émigré en d' autres endroits, étaient devenus rares et avaient passé presque à l'état de pygmées ou avaient été peut-être entièrement anéanties pendant quelques temps, et tout cela non par suite d'un changement de climat, mais d'une altération du sol, du fond de la mer, de la station où ces êtres devaient demeurér. Bronn, "Supp. Comptes Rendus," t. 2. p. 724.

‡ Explanation of Quarter-Sheet, 98 N.E., p. 10.

Nearly every fossil of the Winder Grit band occurs, however, in the Wenlock rocks of Siluria.

The study of the American Silurians affords another example of recurring forms. Dr. Nicholson has shown that certain species which occur in the Lower Silurian of the Hudson River group, recur in the Clinton beds, which form the base of the Upper Silurian, without being found in the intermediate strata; but that in the district far away, in the Anticosti group of Canada, the same species are found which occur in the upper and lower beds of the former district.*

As partly bearing on "Colonies," allusion may be made to the observations of Dr. Dawson in his very interesting address to the Natural History Society of Montreal, in 1874, which show that along the Nova Scotia coast there has been in comparatively modern times a series of changes which have affected not only the seas but the land of that area. He states that around some parts of the Bay of Fundy and the Acadian Bay, there are depressed peat bogs with pine stems, varying from 30 to 60 feet in depth, showing the depression which that area has undergone within comparatively modern times; but he has pointed out, from his own observations, and those of Mr. Verrill, that in some parts of that area there are still a few lingering species of Mollusca which are known to be inhabitants of New England to the south, associated now with a more or less Arctic fauna. Dr. Dawson suggests that these pine forests show that the land must have stood at a higher elevation when they lived and thrived upon the shore of the then Bay of Fundy, and that they had been subsequently depressed; that during the time when they stood at a higher elevation the climatic conditions were different to what they are at present; that the colder seas would be thrown further out, and that the warmer seas would bathe the shore, so that the species now living in the more southerly area migrated northwards, over a larger space than they now occupy; that with the depression of the land and the submergence of these forests the climatic changes were partly reversed—colder conditions arose and the Arctic seas returned, bringing with them the Mollusca and associated fauna which previously existed in that area; thus partly representing the "Colonies" of Barrande, in that remnants of the southern are mixed with the

* Transactions Edinburgh Geological Society, Vol. 3, p. 3.

Arctic fauna, and then unfavourable conditions arising for the continuation of the southern forms, they would gradually die out and be replaced by Arctic ones.

These are a few of the general facts showing the caution which should be exercised with regard to the study of the conditions under which apparently similar deposits either in very closely connected or widely separated areas have taken place.

SUCCESSION OF LIFE.

I will now offer a few remarks on the question, how far a study of the series of animal forms found fossil in the various strata of different geographical provinces assists us in tracing the past history of the life of the earth.

The evidence derived from a general study of the terrestrial forms in the present divisional provinces, points to the fact that there is *not only* a similarity between existing forms and those whose remains are found fossil in the deposits which immediately preceded the present period in each separate province, but a great successive resemblance in the still older faunas,* when each province is compared with the others.

The animal kingdom is divided into six great types or Sub-Kingdoms—Protozoa, Cœlenterata, Annuloida, Annulosa, Mollusca, and Vertebrata—to which groups all the fossil remains belong, so that there is no new type in the broadest signification of the word, and no lost type. There are, however, many extinct families, genera and species, but Nature has retained the same type. In the language of the Poet—

> "So careful of the type she seems,
> So careless of a single life."

In studying the conditions of life, past and present, it will be observed that (1) the lower forms of Invertebrata are more widely distributed than the higher forms of Vertebrata, and that (2) the larger the division a Sub-kingdom or Class, the wider is its distribution in space and the longer is its range in time; and the smaller the group as the genus, and still more the species, the more restricted is its vertical and horizontal distribution. So that there are localized species at the present day in certain areas, and special or characteristic species in the different formations.

* Darwin, "Origin of Species," p. 349.

THE PROTOZOA.—The Foraminifera are widely distributed in time and space. They are found in all seas, and constitute in some places a considerable portion of the ooze of the Atlantic. They range through all the geological series, being present in some band or other of each formation, and even constitute the mass of some limestones, as *Fusulina* in the Carboniferous of Russia, of Tyrol and Ohio. The Chalk, the Nummulitic Limestone of Egypt, the Alps and Spain, the Miliolitic Limestone of Paris, the *Alveolina* Limestone of Bracklesham, and the *Amphistegina* Limestone of New South Wales, are foraminiferal deposits.

Unlike the higher forms of Invertebrata, both genera and species of Foraminifera have a long range in time. Some genera are widely represented in the same geological horizon, as *Fusulina* in the Carboniferous of Russia, North and South America, Sumatra, Tyrol, the Arctic Regions, California, and Armenia. This genus is also found in the Permian Limestones of New Mexico and Texas.*

So also *Nummulina*, which occurs in the Carboniferous and in the present seas, had a wide distribution in the Eocene period, ranging from Bracklesham and Spain to China and Sumatra.†

As Mr. H. B. Brady has lately shown, some of the earliest Foraminifera (Carboniferous) have the highest organization of their group, and indeed we may quote Carpenter, Dawson, and Jones for Laurentian Eozoon having the same standing. Contemporary with these high class Foraminifera, Mr. Brady shows that some forms, like *Nodosaria*, have structureless shells, and others, quite similar in appearance, put on a hyaline character, and that indeed this double habit may represent the original and passage condition of these simple forms, which are now differentiated into long *Lituolæ* on one hand, and the neat compact *Nodosaria* on the other.

Prof. Rupert Jones remarks that *Miliola* among the "Porcellanous," *Trochammina* and *Lituola* among the "Arenaceous," *Textilaria*, *Nodosarina*, *Globigerina*, *Pulvinulina* and *Planorbulina* among the "Hyaline" Foraminifera, are the chief of the genera of

* Brady, "Geological Magazine," Vol. xii, p. 538.

† Few of the Nummulites have a wider distribution than *N. Ramondi*—from the south-west of France, eastwards through Central Europe, North Africa and Asia; indeed almost everywhere wherever the early Tertiary Nummulitic strata appear. H. B. Brady, Geol. Mag., Vol. xii, p. 534.

longest (known) existence, that is beginning before the Cretaceous period, and living now.*

He has further indicated that nearly fifty of the so-called species or "notable varieties" of the Foraminifera, are common to the Cretaceous rocks, and the present seas.† The general distribution of the Foraminifera in time may be given as follows, the

Perforate and Hyaline Foraminifera—Laurentian to Recent.

Imperforate { Porcellanous—Lias to Recent.
Arenaceous—Carboniferous to Recent.

The Orders belonging to the other division, Spongida of the Protozoa, as the Hexactellenida, Lithistida and Calcispongia are considered to be more or less represented in the geological series, the spicula of siliceous sponges sometimes constituting beds of chert and flint in the Cretaceous rocks, where also the Hexactenellid genus, *Ventriculites*, is a characteristic form.‡

Cœlenterata.—The Sub-Kingdom, Cœlenterata, is widely distributed in space, but the two Classes—Hydrozoa and Actinozoa are equally distributed in time; the latter, from the stony nature of the skeleton, is well represented through all the geological periods, and constitutes in some formations extensive coral reefs.§

The Oldhamiæ and Graptolitidæ have been referred to the Hydrozoa; both are extinct forms, and the Graptolites, under many

* T. R. Jones, "On the Range of the Foraminifera in Time," Proc. Geol. Assoc., Vol. 2, p. 180.

† See Prestwich, Ann. Address, Geol. Soc. 1871, p. li.; also Morris, "Geology of Croydon," p. 7, where a list of the forms is given; and "Cretaceous Rotalinæ," Jones and Parker, Quart. Jour. Geol. Soc. May, 1875.

‡ The genera at present known in the Silurian (*Eospongia, Archæocyathus, &c.*) differ in essential characters from the later Hexactellenida, and possibly required other conditions of life than their successors. In the Devonian and Carboniferous Limestone, and in the Dyas, the Order is as yet represented by only insufficiently investigated genera, [referred to as] *Acanthospongia*, Carb., and *Bothroconus*, Dyas. In the Trias and Lias no Hexactellenida are at present known, and in the Lower Oolites they are very scarce. The Upper Jura exhibits a rich development of the Order and also of Lithistida, but only where it occurs in the form of limestone. In the lower and middle stages of the Cretaceous formation (except where they present a deep-sea facies) the Hexactellenida occur but sparingly. The greatest variety of fossil Hexactellenida and Lithistida is furnished by the Upper Cretaceous division, but only by such deposits as the White Chalk of deep-sea origin. Although they are scarce in the Eocene deposits, M. Pomel has discovered numerous Miocene sponges in the province of Oram. In formations which are at present known under a littoral facies, there are no Hexactellenida, and thus the different sponge horizons are in part separated by enormous intervals of time. Zittel, Ann. Nat. Hist., Ser. 4, Vol. xx., p. 421.

§ Duncan, Quart. Journ. Geol. Soc., Vol. 26, p. 51.

genera, are especially characteristic of the Silurian period.* *Palæocoryne* is found in the Carboniferous rocks, but indications of the other Orders were considered obscure. *Millepora* and its allies, formerly classed with the Tabulata, are now shown to belong to the Hydrozoa.† The Rugosa, Favositidæ, and Thecidæ are characteristic Palæozoic forms; the former is almost extinct, having but one genus, *Holocystis* in the Cretaceous, one in the Tertiary of Australia, *Conosmilia*, and two living genera, *Haplophyllia* and *Guynia*.‡ The Favositidæ diminish in numbers through the Mesozoic and Tertiary to the present time. One Palæozoic genus, *Chætetes*, occurs in the Trias. The Tubulosa are Palæozoic. The Aporosa (for *Palæocyclus* belongs to the Rugosa) commence in, and is the chief order of Jurassic§ corals, associated with some of the Perforata; both of these Orders occur somewhat abundantly in the Cretaceous and Tertiary rocks, and comprise most of the reef-building and deep-sea corals of the present seas. The Alcyonaria are found in the Palæozoic (*Protovirgularia*), Cretaceous and Tertiary, and the researches of Mr. Moseley have shown that *Heliolites* and other Silurian genera (*Propora*, *Plasmopora*, &c.),‖ closely related to *Heliopora*, do not belong to the Tabulata, but to the Alcyonaria, thus adding more of this group to the Palœozoic period, while *Millepora*, formerly classed with the Tabulata, should be referred to the Hydrozoa.¶

The Sclerobasic corals first appear in the Tertiary strata.**

* Lapworth and Hopkinson, Quart. Journ. Geol. Soc., Vol. 31, p. 634. Nicholson, Ann. Nat. Hist., Nov., 1868. Hopkinson, Journ. Quek. Mic. Club, Vol. I.

† Moseley, "Philosophical Transactions," Vol. 166, p. 91.

‡ Prof. Duncan states: "There can be no doubt about the persistence of the rugose type of Palæozoic Madreporaria through the Neozoic formations to the present time, and that the species with hexameral and decameral septal arrangements descended from rugose types, and the latter especially from those with an indefinite septal number." On the Structure of Guynia, Phil. Trans. 1872. See also Trans. Zool. Soc., Vol. 8, p. 335.

§ According to Verrill the Z. perforata were represented in the Silurian seas. "American Journal," p. 194, 1872.

‖ Dolfuss classes the Héliolitiens with the modern Milléporiens. "Comptes Rendus," Tome 80, p. 681, 1857.

¶ Moseley, "Philosophical Transactions," Vol. 166. p. 91.
The group of the Tabulata ceases to exist, and its members must be grouped either with the Hexacoralla, the Octocorolla, or the Hydrozoa. Huxley, "Manual of Invertebrata," p. 166. See also Duncan, Brit. Assoc. Report, 1871.

** For the distribution and characters of the Cœlenterata, see the valuable Manual by J. R. Greene, London, 1861, from which the Table is compiled.

RANGE OF CŒLENTERATA.

		Palæozoic.				Mesozoic.			Tertiary.			
		S	D	CB	P	TR	J	CR	EO	MI	P	PL	R
Actinozoa.													
Zoantharia ...	...												
Malacodermata	...												
Sclerodermata	...												
Aporosa ...	...												
Turbinolidæ	...	...	...	...	...	...	●	●	●	...	...	...	●
Desmidæ ...	...	...	...	...	...	...	●	...	●				
Oculinidæ	...	...	...	...	...	...	●	●	●	..	...	...	●
Stylophoridæ	...	...	...	...	...	..	...	..	...	●	...	...	●
Astreidæ ...	...	...	...	...	...	●	●	●	●	●	...	...	●
Fungidæ ...	...	...	...	...	...	...	●	●	...	...	●	...	●
Perforata													
Madreporidæ	...	...	...	...	...	..	...	●	...	●	...	...	●
Poritidæ ...	...	●	●	...	...	...	●	...	...	●	...	...	●
Tubulosa ...	...												
Auloporidæ	...	●	●	●									
? Tabulata ...	...												
Thecidæ ...	...	●											
Favositidæ	...	●	●	●	●	●	...	●	...	...	...	...	●
Sclerobasica	...	..	...	...	...	...	...	...	...	●	...	...	●
Rugosa ...	...	●	●	●	●	...	...	●	...	●	...	...	●
Alcyonaria													
Pennatulidæ	...	●	...	...	...	...	...	●	●	...	...	...	●
Gorgonidæ	...	...	...	...	...	...	...	●	...	...	...	...	●
Heliolitidæ	...	●	●	●									●
Hydrozoa.													
Seriatoporidæ	...	—	●	●	...	...	...	...	—	...	...	...	●
Milleporidæ	...	●	●	●	●	...	●	●	...	●	...	●	●
Sertularidæ...	...	●											●
Graptolitidæ	...	●											

Annuloida.—Of this Sub-Kingdom, the Echinodermata, under various modified forms, has a long range in time, from the Cambrian upwards, and presents the same succession in distant areas as that in Britain.

Of the eight Orders (see Table) composing this Class, three, Cystidea, Blastoidea and Edrioasteridæ, are extinct, and characteristic of the Palæozoic period; the Crinoidea, very abundant in the same period, gradually diminishes as an Order in Jurassic and succeeding periods, and is but feebly represented at the present day; two of the families are, however, somewhat persistent—the Pentacrinidæ and Apiocrinidæ, which extend from the Lias and Oolite through the Cretaceous to the present time, where the *Pentacrinus* and *Rhizocrinus* are the respective living forms.

Pentacrinidæ—*Pentacrinus*, Lias, Oolite, Cret, Tert, Recent.

Apiocrinidæ—*Apiocrinus* and *Millericrinus*, Oolite; *Bourgueticrinus*, Cretaceous; Bathycrinus and Rhizocrinus,* Recent.

The free Crinoids are but few, the *Marsupites* and *Glenotremites* of the English Chalk, and the *Uintacrinus* of the American Cretaceous are now represented by the genus *Comatula*, or *Antedon*.

The orders Asteroidea and Ophiuroidea, commencing in the Cambrian, are fairly abundant in the Silurian rocks, and are well represented in the succeeding formations to the present time.

The true Echinoidea, under various forms, range from the Silurian upwards. In the Palæozoic rocks they are represented by a peculiar and characteristic family, the Palæchinidæ or Perischoechinidæ, which differs from the Neoechinidæ in having more than two rows of interambulacral and sometimes of ambulacral plates, and a greater number of genital and ovarial pores.† Some of the forms closely resemble the living genera, *Phormosoma* and *Calveria*, in the flexible nature of the testaceous covering and overlapping plates, to which the Cretaceous genus, *Echinothuria*, seems also allied.‡

The Neozoic and recent Echini are divisible into two sections, the regular and irregular echinoids or Endocyclica and Exocyclica, according as the vent is within or without the ambulacral areas. The former or less organized forms (Cidaridæ, &c.), commence earlier in time than the latter (Spatangidæ, &c.).

The genus *Cidaris* ranges from the Trias, and the family Saleniadæ from the Oolites, and has a living representative.

RANGE OF ECHINODERMATA.

	Cambrian.	L. Silurian.	U Silurian.	Devonian.	Carboniferous.	Permian.	Trias.	Jurassic.	Cretaceous.	Eocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
Holothuroidea							?							•
Asteroidea	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ophiuroidea		—	—	—	—	—	—	—	—	—	—	—	—	—
Echinoidea			—	—	—	—	—	—	—	—	—	—	—	—
Crinoidea	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Blastoidea			—	—	—									
Cystoidea	—	—	—	—										
Edrioasteridea		—												

* Thomson, "Depths of the Sea," figs. 72, 73.

† Keeping, "Palæozoic Echini," Quart. Journ. Geol. Soc., Vol. 32, p. 35.

‡ Woodward, "The Geologist," Sept., 1863. Thomson, "Depths of the Sea," p. 156.

RANGE OF THE ECHINOIDEA IN TIME.

Perischoechinidæ ...			—	—	—									
Neoechinidæ														
I. *Endocyclica*														
Cidaridæ ...							—	—	—	—	—	—	—	—
Hemicidaridæ ...							—	—	—					
Echinidæ ...								—	—	—	—	—	—	—
Diademadæ								—	—	—	—	—	—	—
Saleniadæ ...								—	—	—	—			—
II. *Exocyclica*														
Echinoneidæ									—	—	—	—	—	—
Clypeasteridæ ...									—	—	—	—	—	—
Cassidulidæ								—	—	—	—	—	—	—
Echinoconidæ ...								—	—					
Collyritidæ								—	—					
Ananchytidæ								—	—					
Spatangidæ									—	—	—	—	—	—

ANNULOSA.—The next Sub-Kingdom, the Annulosa, contains a number of Orders of great interest to the Palæontologist, but whose distribution is not uniform, as seen from the following table, which is partly compiled from the elaborate catalogue of fossil Crustacea, prepared by Mr. H. Woodward.*

RANGE OF CRUSTACEA AND ANNELIDA.

	Cambrian.	L. Silurian.	U. Silurian.	Devonian.	Carboniferous.	Permian	Trias.	Jurassic.	Cretaceous.	Eocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
CRUSTACEA.														
Brachyura ...	...	...	...	...	...	...	...	*	*	*	*	*	*	*
Anomura ...	...	...	...	.	...	...	...	...	*	*	...	...	...	*
Macrura ..	..	...	...	...	*	...	*	*	*	*	*	*	...	*
Stomapoda ...	...	...	...	...	*	...	...	*	*	*	...	...	...	*
Isopoda ...	...	...	...	*	*	...	..	*	*	*	..	...	...	*
Trilobita ...	*	*	*	*	*	...	...	...	...	...	...	...	...	...
Amphipoda ...	...	...	*	...	*	*	...	*	...	...	...	...	...	*
Xiphosura ..	...	...	*	...	*	..	...	*	..	...	...	...	...	*
Eurypterida ...	...	...	*	*	*	...	...		...	...	...	...	...	...
Phyllopoda ...	*	*	*	*	*	*	...	*	*	...	...	...	...	*
Ostracoda ...	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Balanidæ ...	...	...	..	...	...	...	...	...	*	*	*	*	*	*
Lepadidæ ..	...	...	* ?	...	...	...	...	*	*	...	...	...	...	*
Myriapoda ..	...	...	...	...	*	...	...	...	...	...	...	...	...	*
ANNELIDA ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Tubicola ...	...	*	*	...	*	...	...	*	*	*	...	...	...	*
Errantia ...	■	*	...	...	...	...	...	*	...	...	...	...	...	*

* "A Catalogue of British Fossil Crustacea, with their synonyms, and the range in time of each genus and order," by H. Woodward, F.R.S. London: Printed by order of the Trustees, 1877.

From this table it is seen that the two Orders which are extinct, are also characteristic of the Palæozoic period, the Eurypterida and Trilobita, and that the lower organized forms, the Ostracoda and Phyllopoda range throughout all geological formations, while the higher forms of Crustacea, as the Macrura and Brachyura, do not appear until a later period of the earth's progress; and of these again, the less centralized Macrura appear earlier than the Brachyura: so, in the Merostomata, the more segmented Eurypterida become extinct in the Palæozoic period, while the higher Xiphosura are continued to the present time. Among the Crustacea, the genus *Estheria* is the most persistent form, as it ranges from the Old Red Sandstone, and is now living in the freshwaters of Brazil and Natal.

The two orders of Annelida are represented throughout all the geological periods; the shelly coverings of the Tubicola being preserved in most of the successive formations, from the Silurian upwards; the genera *Serpula* and *Spirobis*, from their range may be considered as persistent types, while the Errantia "are abundantly represented by their trails upon old sea-bottoms, or their burrows in sand and mud; remains of which occur in all formations, almost from the Lower Cambrian up to the present day."*

The Insecta, Arachnida and Myriopoda commence in the Palæozoic period, the last two in the Carboniferous, and the former in the Devonian of Canada.

The remains of insects are found in most of the geological formations, from the Devonian to the present time, as shown in the table.

RANGE OF INSECTA.

		Palæozoic.			Mesozoic.				Tertiary.			
		S.	D.	C.	P.	TR.	J.	CR.	E.	MI.	P.	PL.	R.
Insecta.		...	●	●	...	●	●	●	●	●	●	...	●
Lepidoptera ...	...	...	...		...	...	?	...	●	●		...	●
Diptera ...	...	...	...		...	...	●	...	..	●		...	●
Hymenoptera ..	...	...	...		...	...	●	...	...	●		...	●
Hemiptera ...	...	...	...	●	...	●	●	...	...	●		...	●
Coleoptera ...	...	...	...	●	...	●	●	...	...	●		●	●
Orthoptera ...	..	...	●		...	●	●	...	...	●		...	●
Neuroptera ...	...	...	●		...	●	●	...	...	●		...	●
Palæodictyoptera	...	...	●	?	...	...	...	...	...	...		...	...
Arachnida ...	...	..	...	●	...	...	...	...	●	●	...	...	●

With regard to their first occurrence, as far as present

* Nicholson, "Manual of Palæontology," p. 141.

researches show,* the Orthoptera and Neuroptera appear in the Devonian, Coleoptera, and Hemiptera in the Carboniferous, Hymenoptera and Diptera in the Jurassic, and probably also the Lepidoptera represented by the *Palæontina oolitica*, the affinity of which is doubted by some entomologists; however in Tertiary strata Lepidoptera undoubtedly occur.†

In the Miocene strata of Switzerland no fewer than nine hundred species of insects have been noticed by Prof. Heer, belonging to all the Orders, of which the Coleoptera number more than five hundred, and associated with them are about seven hundred species of phanerogamous plants.

Mr. Herbert Goss, F.L.S., who has paid great attention to the subject, informs me that:—"The Neuroptera is certainly the oldest Order, as the only six specimens of insects as yet discovered in Devonian strata have all been referred to it; but as three or four of these Devonian insects exhibit characters common both to the Neuroptera and Orthoptera, Dr. Goldenberg had placed them in an extinct Order, which he has called Palæodictyoptera. Several species referable to this extinct Order, as well as a number of true Neuroptera, have also been discovered in the Coal Measures.

"The next Order to appear was the Orthoptera, which is better represented than any other Order in the Carboniferous period, no less than 51 species from the Coal Measures having, up to the present time, been named and described.

"The Coleoptera and Hemiptera are also represented in the Coal Measures, but as yet only two specimens of the former and three of the latter have been detected therein. A few specimens of the Coleoptera have been found in the Trias, but in no rocks of older date than the Lias have specimens of either that Order or the Hemiptera been obtained in any numbers. From the Lias of the Swiss Alps no less than 116 species of Coleoptera have been discovered, and some 29 species have been determined from British strata of that period. The Hemiptera are also tolerably well represented both in the British and Foreign Lias.

"The Orders next to appear on the Geological horizon seem to have been the Hymenoptera and Diptera, but the exact date of the first appearance of either of them is uncertain. A few doubtful

* Lubbock, "Origin and Metamorphoses of Insects."

† Taylor, "Popular Science Review," Jan. 1878, p. 41. "Facts and Arguments for Darwin," Translated by W. S. Dallas, 1869, p. 119.

fragments of the Hymenoptera have been recorded from the Swiss Lias and the Solenhofen Slate, and in this country a few specimens have been obtained from the Purbecks. A few remains of Diptera have been recorded from the Solenhofen Slate, and several from the English Purbecks; but neither specimens of this Order nor of the Hymenoptera are found in any numbers in any strata below the Tertiaries.

"The most recent Order is undoubtedly the Lepidoptera, as with the exception of a few specimens from the Jurassic rocks, most of which are very doubtful, the specimens recorded are all from Tertiary strata.

"You will observe that the Orders comprising the flower-feeding species have been the last to appear, and these species have not been found in any numbers prior to the period at which the dicotyledonous plants attained their highest state of development."

MOLLUSCA.—The Molluscs, so important to the Palæontologist, from their abundance, present some points of interest and significance with regard to their distribution, which seem to involve more than the law of succession, and partly suggests another enquiry—how far function was one of the plans of creative intelligence in maintaining the balance of power in the past economy of Nature?

Among the different Classes of Mollusca, as well as their subdivisions, there is a certain unequal and peculiar distribution. The highest and the lowest Classes, Cephalopoda and Brachiopoda have a long range in time; they were largely developed in the Palæozoic period, when many genera became extinct.

The Cephalopoda, which present various modifications in their generic forms, are divided into two Orders—the Dibranchiata and Tetrabranchiata, which, however, commenced at distinct periods of time. The Dibranchiate group, considered to represent the higher forms, make their first appearance, so far as the present evidence goes,* only in the Mesozoic rocks, and gradually increase to the present time, whereas the other division, Tetrabranchiata, swarmed in the seas of the Palæozoic period with genera of the families Nautilidæ and Orthoceratidæ, and in the Mesozoic, with the Ammonitidæ, while in the Tertiary are a few species of *Nautilus*,

* Prof. Williamson says, in the Silurian age these cuttle fishes were represented by the Orthoceras. "Manchester Science Lecture," 1877, see p. 11 and p. 32.

which persistent genus is the only representative of the Order at the present time.*

The fossil Pteropods and Heteropods are almost wholly Palæozoic forms, so that their succession cannot easily be traced, for in the Mesozoic, except *Bellerophina* (Gault) and a few in the Tertiary, their remains are wanting.

RANGE OF CEPHALOPODA, PTEROPODA, AND HETEROPODA.

	Cambrian.	L. Silurian.	U. Silurian.	Devonian.	Carboniferous.	Permian.	Trias.	Jurassic.	Cretaceous.	Eocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
CEPHALOPODA DIBRANCHIATA.														
A. Octopoda														
Argonautidæ ...	...	...	...	...	...	...	...	...	...	...	...	●	...	●
Octopodidæ ...	...	...	...	...	...	...	...	...	...	...	...	...	...	●
B. Decapoda														●
Teuthidæ ...	...	...	...	...	...	...	...	●	...	●	...	...	...	●
Sepiadæ ...	...	...	...	...	...	...	...	●	...	●	●			●
Belemnitidæ ...	...	...	...	...	...	...	...	●	●	?				
Spirulidæ ...	...	...	...	...	...	...	...	...	...	...	...	...	...	●
TETRABRANCHIATA.														
Nautilidæ ...	...	...	●	●	●	●	...	●	●	●	●	...	...	●
Orthoceratidæ ...	●	●	●	●	●	...	●							
Ammonitidæ ...	...	...	●	●	●	...	●	●	●					
PTEROPODA.														
Gymnosomata ...	...	...	...	...	...	...	...	...	...	...	...	...	...	●
Thecosomata ...	●	●	●	●	●	...	...	...	...	●	●	●	...	●
HETEROPODA.														
Firolidæ ...	...	...	...	...	...	...	...	...	...	...	●	...	...	●
Atlantidæ ...	...	●		●	●	...	●	...	●	...	...	...	...	●

M. Barrande describes nearly 90 species of *Theca*, more than 80 species of *Conularia*, and about 50 species of *Tentaculites* from the Palæozoic rocks.

The Gasteropoda present some interesting facts in their distribution. There are two chief divisions—one in which the shell has an entire aperture, and the other which has the aperture more or less notched or prolonged into a canal. These two divisions, as far as our knowledge of the habits of the recent animals

* M. Barrande enumerates 26 genera, and subgenera of Cephalopoda, containing 2,812 species in the Palæozoic rocks. The persistent genus, Nautilus, has 119 Palæozoic, 167 Mesozoic, 19 Tertiary, and three recent species.

extends, are thus differentiated: the Holostomata are chiefly herbivorous, although some of them, as the Naticidæ, are animal feeders, while the Siphonostomata include those families which are mostly flesh-eaters or zoophagous.

The distribution in time of these two divisions is shown in the table. It will be seen that the Holostomata were abundant in the Palæozoic seas, while there is scarcely any trace of the Siphonostomous Molluscs during the same period, from which the inference arises that co-existent with these Holostomata there must have been some vegetable matter, though apparently all traces of it are nearly lost in the Lower Palæozoic rocks.*

The Holostomata, comparatively abundant in the Palæozoic period, were equally or even more abundant in the Mesozoic, and also in the Tertiary period, but the Siphonostomata, entirely wanting in the Palæozoic period, commence in the Mesozoic, and become far more largely developed in the Tertiary than in any preceding period.†

The great abundance of the Cephalopoda in the Lower Palæozoic, and of carnivorous fish in the Upper Palæozoic, may have partly represented and compensated for the absence of the Siphonostomata in modifying the increase of the herbivorous and other Mollusca of those periods.

The Pulmonifera are not only widely distributed at present, but range far back in time, *Pupa* and *Helix* (Zonites) being found in the Carboniferous rocks of Nova Scotia; *Physa*, *Planorbis*, *Valvata*, and *Limnea* (?) occur in the Purbeck beds and succeeding Tertiary freshwater strata, although absent in the Wealden, where they are replaced by the branchiferous genus, *Paludina*.

Among the freshwater bivalves two or three genera may be considered persistent forms; thus the genus *Anodon* is found in the Old Red Sandstone, and although not yet noticed in the Mesozoic rocks, is continued through the Tertiary period. *Cyrena* ranges from the Lower Oolites upwards, and is now restricted to the freshwaters of Africa and Asia. *Unio* and *Cyclas* are widely distributed, the former ranging from the Lower Oolite and the latter from the Tertiary strata.

* Anthracitic and carbonaceous shales and Fucoidal schists have been noticed in the Lower Silurian.

† A set of extensive tables prepared by Mr. J. Logan Lobley some years ago were exhibited at the meeting, which showed in a novel manner the distribution of the families, genera, and the numerical proportion of the species in the various formations, and thus rendered the subject very intelligible.

RANGE OF GASTEROPODA.

	Cambrian.	Silurian.	Devonian.	Carboniferous.	Permian.	Trias.	Jurassic.	Cretaceous.	Eocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
I. PROSOBRANCHIATA.													
Siphonostomata.													
Strombidæ	...	...	...	...	...	...	●	●	●	●	●	●	●
Muricidæ	...	...	...	...	...	...	...	●	●	●	●	●	●
Buccinidæ	...	...	...	...	...	...	●	...	●	●	●	●	●
Conidæ	...	...	...	...	...	...	...	...	●	●	●	●	●
Volutidæ	...	...	...	...	...	...	...	●	●	●	●	●	●
Cypræidæ	...	...	...	...	...	...	...	...	●	●	●	●	●
Holostomata.													
Naticidæ	...	...	●	●	...	...	●	●	●	●	●	●	●
Pyramidellidæ ...	...	●	●	●	...	●	●	●	●	●	●	●	●
Cerithiadæ	...	...	...	...	...	●	●	●	●	●	●	●	●
Melaniadæ	...	...	...	...	...	...	●	...	●	●	●	...	●
Turritellidæ ...	...	●	...	●	●	...	...	●	●	●	●	...	●
Litorinidæ	...	...	...	...	●	...	...	...	●	...	●	●	●
Paludinidæ... ...	...	...	...	...	...	...	●	●	●	...	...	●	●
Neritidæ	...	●	●	●	...	...	●	...	●	...	...	●	●
Turbinidæ	...	●	●	...	...	●	●	...	●	●	●	...	●
Haliotidæ	...	●	●	●	...	...	●	●	...	...	...	...	●
Fissurellidæ ...	...	...	...	...	...	●	●	●	●	...	●	●	●
Calyptræidæ ...	...	...	●	●	...	...	...	●	●	...	...	...	●
Patellidæ	...	...	...	●	...	...	●	...	●	●	●	●	●
Dentalidæ	...	...	●	●	...	...	●	●	●	●	...	...	●
Chitonidæ	...	●	...	●	...	...	...	...	...	...	...	...	●
II. OPISTHO-BRANCHIATA.													
Tornatellidæ ...	...	...	...	●	...	...	●	●	●	...	●	...	●
Bullidæ	...	...	...	...	...	...	●	...	●	●	●	...	●
III. PULMONIFERA.													
Inoperculata ...	...	...	...	●	...	...	●	...	●	●	●	●	●
Operculata	...	...	...	...	...	...	...	...	●	...	●	●	●

Of the Holostomatous forms referred to, the following living genera have been noticed in the Palæozoic rocks :—*Capulus*, *Chiton*, *Chemnitzia*, *Dentalium*, *Turbo*, *Turritella*, and *Pleurotomaria*; the latter, abounding in the Secondary rocks, is scarcely represented in the Tertiary, and has one living species. On the other hand, the Siphonostomous families Conidæ, Volutidæ, and Cypræidæ are nearly restricted to and characteristic of the Tertiary rocks.

The Lamellibranchiata, or bivalve Molluscs, are divided into Asiphonida and Siphonida, according as they are without or provided with siphonal tubes.

The greater number of the Palæozoic bivalves belong to the

Asiphonida, as the Aviculidæ, Arcadæ, Mytilidæ,* with some Siphonida as Cardiadæ and Cyprinidæ; on the other hand, the sinupalleal Siphonida are feebly represented in the Palæozoic rocks, but most of the families commence in the Mesozoic period, and attain their maximum of species in the Tertiary, while the greatest development of the Asiphonida is in the Jurassic strata.†

The Siphonida are further arranged in two divisions—Integropalleal and Sinupalleal—dependent on the palleal line being entire or more or less broken by a deep inflexion or sinus. These two divisions present somewhat different structures, and have different habits; those with a sinus have more or less elongated tubes for the purpose of aeration, and mostly burrow in the sand, mud, or rock; those with the palleal line entire have no tubes, or very short ones.

RANGE OF LAMELLIBRANCHIATA.

	Cambrian.	Silurian.	Devonian.	Carboniferous.	Permian.	Trias.	Jurassic.	Cretaceous.	Eocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
I. ASIPHONIDA—													
Ostreidæ	...	...	...	...	...	●	●	●	●	●	●	●	●
Aviculidæ	...	●	●	●	...	●	●	●	●	...	...	...	●
Mytilidæ	●	●	...	●	●	...	●	...	●	●	●	●	●
Arcadæ	●	●	●	●	...	●	●	●	●	●	...	...	●
Trigoniadæ	...	●	...	●	●	●	●	●	...	...	...	...	●
Unionidæ	...	...	●	...	...	...	...	●	●	●	●	●	●
II. SIPHONIDA—													
A. *Integropalliala*													
Chamidæ	...	...	...	...	...	...	●	●	●	...	...	...	●
Hippuritidæ	...	...	...	...	...	...	...	●					
Tridacnidæ	...	...	...	...	...	...	...	...	...	●	...	...	●
Cardiadæ	...	●	..	●	...	●	●	●	●	...	...	...	●
Lucinidæ	..	?	...	...	...	...	●	...	●	●	●	...	●
Cycladidæ	...	...	...	...	...	...	●	●	●	...	...	●	●
Cyprinidæ	...	?	●	●	●	●	●	●	●	●	●	●	●
B. *Sinupalliala*													
Veneridæ	...	...	...	...	...	...	●	●	●	●	●	...	●
Mactridæ	...	...	...	...	...	...	?	...	●	●	●	...	●
Tellinidæ	...	...	...	...	...	...	●	●	●	●	●	...	●
Solenidæ	...	...	...	...	...	...	...	●	●	...	●	...	●
Myacidæ	...	...	...	...	...	...	●	●	●	●	●	...	●
Anatinidæ	...	●	...	●	●	...	●	●	●	...	...	...	●
Gastrochænidæ	...	...	...	...	...	...	●	●	...	...	●	...	●
Pholadidæ	...	...	...	...	...	...	?	●	●	...	●	●	●

* Phillips' "Memoirs of the Geological Survey," Vol. 2, p. 264.

† Lobley, "Distribution of British Fossil Lamellibranchiata," Quart. Journ. Geol. Soc., 1871, p. 411.

The Hippuritidæ, so characteristic of the Cretaceous rocks of the South of Europe, is the only extinct family of Lamellibranchiata. The more persistent forms of this class are—*Avicula, Modiola, Nucula, Pinna, Solen.*

RANGE OF THE BRACHIOPODA.

	Cambrian.	L. Silurian.	U. Silurian.	Devonian.	Carboniferous.	Permian.	Trias.	Jurassic.	Cretaceous.	Eocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
INARTICULATA—														
Lingulidæ	•	•	•	•	•	•	...	•	•	•	...	...	...	•
Discinidæ	•	•	•	...	•	•	...	•	•	...	...	•	...	•
Craniadæ	...	•		•	•	...	...	■	•	...	...	...	...	•
Trimerellidæ	...	•												
ARTICULATA—														
Terebratulidæ	...	...	...	•	•	•	•	•	•	•	...	•	•	•
Rhynchonellidæ	...	•	•	•	•	•	...	•	•	...	...	•	•	•
Spiriferidæ	...	•	•	•	•	•	•	•						
Orthidæ	•	•	•	•	•									
Productidæ	...	...	...	•	■	•	•							
Thecidiidæ	...	...	...	...	...	...	•	•	■	•	...	...	...	•

The class Brachiopoda is divided into the Inarticulata or Tretenterata and the Articulata or Clistenterata.

The Inarticulata have, with the exception of Trimerella, a long range in time, and thus *Lingula, Discina,* and *Crania* may be considered persistent types differing little from their first appearance.

Rhynchonella and *Terebratula* of the Articulata extend from the Palæozoic rocks to the present time, others range only from the Palæozoic to the Secondary, as *Spirifera* and *Strophalosia;* other genera are restricted to special formations, as *Stringocephalus* and *Davidsonia* to the Devonian, and *Koninckia* to the Trias.*

* Of the 122 genera noticed by Mr. Davidson, 82 are confined to the Palæozoic rocks, nine are peculiar to the Secondary period, and nine are found living only. Again, 9 genera appear for the first time in the Cambrian, 53 Silurian, 21 Devonian, 7 Carboniferous, 2 Permian, 2 Trias, 10 Jurassic, 5 Cretaceous, 2 Tertiary, and 9 in the recent period.—"Qu'est ce qu'un Brachiopode," par Th. Davidson, Traduit par Th. Lefèvre, Ann. Soc. Malac. de Belgique, tome x.; and Geol. Mag., 1877. See also Lobley, "Distribution of British Fossil Brachiopoda," Geol. Mag., Nov., 1868, and Proc. Geol. Assoc., Vol. 2.

The Bryozoa or Polyozoa* occur from the Cambrian rocks upwards, mostly in calcareous deposits, and are represented by many forms chiefly belonging to the Cyclostomata and Cheilostomata. In the Palæozoic rocks all the genera are extinct, and do not range into the Mesozoic, and chiefly belong to the family Fenestrellidæ. In the Jurassic and Cretaceous rocks the Polyozoa are numerous, especially in the latter. In the Tertiary they are also abundant in some deposits, as the Suffolk Crag, where the still living genera, which first appear in the Jurassic strata, increase in numbers.

VERTEBRATA.—Having given, generally, the geological distribution of the Invertebrata, I shall attempt to state briefly some leading facts connected with the range in time of the Vertebrata.

The great groups or types of the Invertebrata and Vertebrata have not a parallel distribution in time.

The five types of the Invertebrata occur together in the Lower Palæozoic rocks, *i.e.*, Lower Silurian, or, perhaps, the Cambrian, while the five types of the Vertebrata appear nearly in the order of their relative organisation, viz., Pisces, Amphibia, Reptilia, Aves and Mammalia.

The Class PISCES, or the fishes, first appear in the Upper Silurian, for thousands of feet of sedimentary strata were accumulated, through long periods of time, during which the Palæozoic sea was only tenanted by the Invertebrata, not only in Europe, but in America. They are represented in the Upper Silurian of Europe (with the doubtful exception of the Conodonts) by a few remains of the genera *Pteraspis* and *Onchus*.

In the Silurians of America no fishes occur; for there they first appear in the Devonian, and among them are some gigantic forms of Placoderms as *Dinichthys* and its allies.

The student of biology and the laws of evolution may pause here and reflect on the fact, that from the geological horizon of *Eozoon Canadense*, we have passed through nearly 18 miles in thickness of oceanic deposits, representing many ages for their deposition, while the changes in the forms of life have been numerous and wonderful, and the development into higher forms constant

* Mr. Pascoe, in his "Zoological Classification," classes the Polyozoa with the Vermes, p. 36.

throughout the whole period. Yet that life had found its complete development in the lowly organised articulate animal—the somewhat awkwardly constructed, loosely thrown together, flimsy *Eurypterus*.*

The Elasmobranchs and Ganoids, which are especially characteristic of the Palæozoic age, also occur in America, but are not so numerous as in the Old Red Sandstone of Europe, where they present remarkable and interesting forms, some of them being allied to the *Polypterus*, and others to the Dipnoid fishes.

The same Orders extend, with different generic forms, through the Carboniferous and Permian strata, and thus these Orders are characteristic of the Palæozoic period.

The Elasmobranchs and Ganoids—the latter with homocercal tails and mostly related to *Lepidosteus*—continue through the Mesozoic period, but are peculiar only to the lower part, the Triassic and Jurassic, for in the Upper Cretaceous the Cestracionts and Chimæroids are associated with the first incoming of the Teleostean fishes, which increase in number in the Tertiary period and constitute the dominant Order in the present seas. The two other Orders are represented in the Tertiary period and at the present time, but considerably diminished in numbers, especially the Ganoids.

Mr. Carruthers,† in his suggestive Address, pointed out that, through long ages of the earth's history, the land plants consisted chiefly of Cryptogams, Gymnogens, and some Endogens, but it was only in the Cretaceous period that Dicotyledonous plants first appeared, showing a somewhat marked relation between the incoming of certain animals and certain plants; at any rate the appearance of Teleostean fish, contemporary with the first known appearance of Dicotyledonous plants, is a singular coincidence.‡

Among the more persistent genera of fish is the *Ceratodus* which occurs in the Trias, Lower and Upper Oolite, and although absent

* Miller, "The American Palæozoic Fossils," Cincinnati, Ohio, 1877.

† Proc. Geol. Assoc., Vol. v., p. 1.

‡ See Plate, p. 220, which has been kindly lent by the Publishers of "Popular Science Review," having been used to illustrate a paper on the Cretaceous Flora, in that Journal, for Jan., 1876.

in the succeeding formations, is now living in the freshwaters of Queensland. The *Beryx* (Ctenoid) of the Chalk is a present Atlantic genus, and the *Lepidosteus* (Ganoid) of the Eocene is the modern gar-pike of the North American rivers, and was represented in the Wealden by *Lepidotus*, and probably in the Trias by *Ischypterus*.

AMPHIBIA first appear in the Carboniferous rocks, represented by the Labyrinthodontia, which extend through the Permian (except in America) into the Trias. No traces of Amphibia have been recorded from the Jurassic and Cretaceous strata of Europe and America. In the Tertiary period most of the forms were related to modern types.

RANGE OF PISCES, AMPHIBIA AND REPTILIA.

	Cambrian.	L. Silurian.	U. Silurian.	Devonian.	Carboniferous.	Permian.	Trias.	Jurassic.	Cretaceous.	Eocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
Teleostei	...	...	...	...	...	...	...	...	●	●	●	●	●	●
Placodermi	...	..	...	●										
Elasmobranchii	...	...	●	●	●	...	●	●	●	●	●	●	...	●
Holocephali	...	...	...	●	?	...	...	...	●	●				
Ganoidei	...	...	...	●	●	●	●	■	●	●	...	...	...	●
Dipnoi	...	...	...	●	●	...	●	...	...	..	...	...	...	●
Ostracostei	...	...	●	●										
AMPHIBIA.														
Urodela	...	...	...	...	...	●	●	...	...	...	...	...	...	●
Batrachia	...	...	...	...	...	...	...	...	...	...	●	...	...	●
Labyrinthodonta	...	...	...	...	●	●	●							
Gymnophiona	...	..	...	...	...	...	...	...	...	...	...	...	...	●
REPTILIA.														
Ophidia	...	...	...	...	...	...	...	...	...	●	●	●	.	●
Chelonia	...	...	...	...	...	?	...	●	●	●	●	..	..	●
Mosasauria	...	...	...	...	...	...	...	...	●					
Lacertilia	...	...	...	...	...	●	●	●	...	●	●	..	...	●
Crocodilia	...	...	...	...	...	...	...	●	...	●	●	●	...	●
Ichthyosauria	...	...	...	...	?	...	?	●	●					
Sauropterygia	...	...	...	...	...	...	?	●	●					
Anomodontia	...	...	...	...	...	...	●							
Dinosauria	...	...	...	...	...	...	●	●						
Pterosauria	...	...	...	...	...	...	...	●	●					
Pteranodontia	...	...	...	...	..	...	...	...	●					
Theriodontia	...	...	...	...	..	?	●							

REPTILIA.—With the exception of some vertebræ referred to *Eosaurus* by Professor Marsh, from the Carboniferous rocks of America, reptiles first appear in Europe with the lizard-like form *Proterosaurus* in the Permian beds of England and Thuringia; in the same formation also occur some remains referred to the Theriodont reptiles, which, however, are more characteristic of the Trias of South Africa.* In the succeeding Triassic and Jurassic rocks most of the Orders of reptiles appear, so that the Mesozoic has been termed the Age of Reptiles from their abundance. During the Triassic period some genera were widely distributed;† among the more remarkable forms are the Deinosauria, which extend to the Cretaceous. The Pterodactyles are both Jurassic and Cretaceous, but on the American continent they are represented in the Chalk of Kansas by an allied Order, without teeth—the Pteranadontia. These toothless Pterodactyles of America are singularly enough associated in the same formation with the remarkable toothed birds, the Odontornithes hereafter noticed.

The Chelonia which commence in the Lower Oolites, except the foot-prints noticed in the Permian, belong to this Order.

Another order of Reptilia is essentially Cretaceous. The Mososauria,‡ although scantily represented in Europe, are the most characteristic reptiles of the American Cretaceous strata, and in the seas of that period "they ruled supreme, as their numbers, size, and carnivorous habits enabled them easily to vanquish all rivals."§

From the table it will be seen that eight of the Orders became extinct during the Mesozoic age, three only, which commenced in that period, extend through the Tertiary to the present time; these

* Owen, "Fossil Reptilia of South Africa," 1877. This order derives its name from the resemblance in the dentition to the class Mammalia.

† Huxley, on the Classification of the Dinosauria. Quart. Journ. Geol. Soc., Vol. 26, p. 32.

‡ Marsh, Address, p. 14.

§ Prof. Owen regards the Mososauria as a family of Lacertilia equivalent to the Iguanodontidæ and Megalosauridæ in the order Dinosauria. The order Lacertilia among Reptiles being equivalent to the order Carnivora or Feræ among Mammals, the Mososaurians would be the equivalents of the Seals in the latter. Proc. Geol. Soc., No. 238, June, 1877.

three—the Chelonia, Crocodilia, and Lacertilia—are, however, associated in the Eocene strata with the Order Ophidia, which appears, for the first time in the Lower Tertiary beds both of Europe and America. In the latter country remains of snakes are abundant in the freshwater Eocene.

The Crocodilia, with their successive amphicœlian, opisthocœlian, and procœlian vertebræ, have a long range in time from the Trias upwards, the former two divisions occur in the Lower Mesozoic rocks; the procœlian, to which the modern forms belong, commence in the Cretaceous of America and in the Eocene of Europe, and extend through the Tertiary.

In the Eocene deposits of England, as shown by Professor Owen, the three existing types are found together—Crocodile, Alligator, and Gavial—but which are now widely separated.*

AVES.—The birds (as at present known) are more restricted in time than the three preceding classes of Fishes, Batrachia, Reptiles, and even than the Mammals, if the foot-prints (*Brontotherium*) on the Triassic sandstones of Connecticut river do not belong to birds, but to reptiles.†

In the succeeding Jurassic strata birds commence with the singular genus *Archæopteryx* (Saururæ); in the Cretaceous rocks of Europe‡ remains of birds are rare, but in similar strata in America they are more abundant, and associated with allied modern forms is a remarkable Order of toothed birds, the Odontornithes, which together with other structures (as the biconcave vertebræ in *Ichthyornis*) present reptilian characters. The struthious birds (Ratitæ), which at the present day are nearly restricted to the southern hemisphere, occur in the Eocene of Europe as *Gastornis* and *Dasornis*, and in the Post-Pliocene of New Zealand, where these are abundant, and of gigantic sizes as *Dinornis*, preceding the now small wingless *Apteryx*. This Order is widely distributed,

* The Alligator is found in the West Indies, the Crocodile in the Nile, and three species of Crocodile in the Ganges associated with the Gavial. Owen, Pal. Soc., 1850.

† The evidence of their presence in the Trias, based on footprints and other impressions, is at present, as we have seen, without value, although we may confidently await their discovery there, if not in older formations. Professor O. C. Marsh, "Address," p. 18.

‡ Seeley, Cretaceous Birds, Quart. Journ. Geol. Soc., Vol. xxxii., p. 496.

from which is inferred its great antiquity, and each genus is restricted to its special province.*

Most of the existing groups of the Carinatæ, to which all the other modern birds belong, are found in the Eocene deposits (represented by extinct genera), and in the succeeding Miocene and later strata. During the Tertiary periods birds were numerous in America.

Mr. S. Wood† has attempted to show (inferring their existence in the Trias) that the modern Struthionidæ exist only in lands which are remnants of Secondary continents; and that as regards all the other wingless birds, except the Struthionidæ, *i.e.*, the birds of Madagascar, the Mauritius, and adjoining Islands, and of New Zealand, they exist only in *isolated* remnants of those continents; and not less significant is it, that these forms of Mammalia and of modern wingless birds are associated with vegetable forms having the nearest affinities to the vegetation of the Secondary and Carboniferous periods—as witness the tree ferns and Cycadeæ of Madagascar, Australia, and New Zealand, and the Araucariæ of various parts of the southern hemisphere; while in the *Cestracion* and *Trigonia* of the Australian shores are preserved the only living examples of those Secondary genera.

RANGE OF AVES.

	Trias.	Jurassic.	Cretaceous.	Eocene.	Miocene.	Pliocene.	Pleistocene.	Recent.
Odontornithes	...	..	*					
Saururæ	..	*						
Ratitæ	?	...	...	*			*	*
Carinatæ	...	...	?	*	*	*	*	*

* The Struthiones or Ratitæ include the African Ostrich, the Rhea of South America, the Emeu of Australia, the Apteryx of New Zealand, and the Cassowary of the Indian Archipelago.

† "On the Form and Distribution of the Land-tracts during the Secondary and Tertiary Periods," by S. Wood, jun. Lond. and Edinb. Phil. Mag., 1862, Vol 23, which paper also contains some valuable and suggestive remarks on the effects upon animal life produced by great geographical changes.

regard to the Mammalia I shall very briefly explain their
ion, as shown by the following table:—

RANGE OF MAMMALIA.

	Trias.	Jurassic.	Cretaceous.	Eocene.	L. Miocene.	U. Miocene.	Pliocene.	Pleistocene.	Recent.
lia	*	*	...	*	*	...	...	*	*
... ...	...	...	...	...	...	*	*	*	*
. ...	...	...	...	*	...	*	*	...	*
. ...	...	...	...	*	...	*	*	...	*
styla	...	...	...	*	*	*	*	*	*
yla	...	...	...	*	*	*	*	*	*
ia	...	...	...	■	*	*	*	*	*
itia	...	...	...	*	*	...	*	*	*
rned Ruminants	...	...	...	...	...	...	*	*	*
tida	...	...	...	*	*	*	*		
ea	...	...	...	...	*	*	*	*	*
a*	...	...	...	*					
ia	...	...	...	...	...	...	...	*	
a†	...	...	...	*					
... ...	...	...	...	*	*	*	*	*	*
ra	...	...	...	*	...	...	...	*	*
ra	...	...	...	*	*	*	*	*	*
. ...	...	...	...	*	*	*	*	*	*
a	...	...	...	...	...	...	...	*	*
da	...	...	...	...	...	...	*	*	*
da	...	...	...	*	*	*	*	*	*
ana	...	...	...	*	*	*	*	*	*
. ...	...		...	...	—	...	...	*	*

e Super-Cretaceous rocks first appears the great incoming Mammalian class—not represented by one form, but by rms. Have we yet to discover any ancestral type, or are consider that in this sudden appearance of a rich fauna, new creative powers were exercised, by which groups of were then introduced upon the surface of the earth?‡

se animals appear to belong to the great Ungulated group, and to position somewhat intermediate to the Perissodactyles and the dea. Professor Flower, "The Extinct Animals of North America," y. Inst., 1876.

bine the characters of Carnivores, Ungulates and Rodents.

essor Marsh remarks—"If the history of American mammals a whole incomplete and unsatisfactory, we must remember the cal tree of this class has its trunk and larger limbs concealed the *débris* of Mesozoic time, while its roots doubtless strike so to the Palæozoic that for the present they are lost. A decade or

This is still a broad and open question. From the table it will be seen that of all the groups represented in the Tertiary period, only one, as at present known, extends far back in time; that is the group of pouched animals or Marsupials.*

In the Triassic rocks of Europe and America, Marsupial mammals first occur; represented in the former country by the *Microlestes* and in America by the *Dromatherium*,† considered to be related to the living *Myrmecobius* of Australia. In the succeeding Oolitic strata other Marsupial genera are found, as *Amphitherium* and *Phascolotherium*, associated with a doubtful form of perhaps higher grade, the *Stereognathus*.

In the Purbeck beds are many forms referred to this Order,‡ and though not found in Cretaceous, they occur again in the Eocene. "The low, comparatively non-differentiated condition of the Mesozoic Marsupials of Europe have been succeeded and finally represented in Europe by differentiated carnivorous climbers (Didelphidæ); but on this continent they did not survive to enter the latter half of the Neozoic period. Our latest European fossil Marsupial is a Miocene Opossum."‡

In the still later Post-Tertiary deposits of South America, Marsupial remains are found nearly related to those now living, and the probably contemporaneous strata of Australia have yielded gigantic forms of Diprotodons, Kangaroos, and others, which foreshadowed the "great diversity and specialisation of structures" which are found in the present varied marsupial fauna so characteristic of the Australian province. Hence arises one of the broader questions which has to be considered with regard to present distribution, viz., under what conditions, or by what means, similar forms to those which lived in the older Mesozoic period are now restricted to the Australian continent?

Mr. Wallace, in alluding to the Marsupials in the Trias of Europe and North America, says, "We have, therefore, every reason

two hence we shall probably know something of the mammalian fauna of the Cretaceous, and the earlier lineage of our existing mammals can then be traced with more certainty." Address, Amer. Assoc. Science, 1877.

See also, Gaudry, "Les Enchainements de Monde Animal dans le temps géologiques," Paris, 1878.

* Owen, "Mesozoic Mammals," Pal. Soc.

† Emmons—"American Geology," part vi., 1857, p. 93.

‡ The "Fossil Mammalia of the Mesozoic Formations," by Prof. Owen F.R.S., Pal. Soc, 1871.

§ *Ibid*, p. 118.

to believe that it was at or near this remote epoch when Australia, or some land which has been since in connection with it, received a stock of mammalian immigrants from the great northern continent; since which time it has almost certainly remained completely isolated."*

The Edentata do not occur in the Eocene; a few are found in the Miocene, including Moropus, but in the Pliocene and Post-Pliocene they are widely distributed, especially in the later deposits of North and South America, and are now the characteristic mammals of the latter country.

The Cetacea first appear in the Eocene both of Europe and America, and are well represented in the Miocene of the latter country by the *Dalphin* family, and are tolerably abundant in the Pliocene (*Crag*) deposits of England and Belgium.

The *Sirenia* occur in the Eocene of Europe, and also in the Miocene of Europe (the genus *Halitherium*), and of America and throughout the later Tertiary; being represented at the present day by the Dugong and Manatee, and until recently by the *Rhytina*, which has now become extinct on the north-west coast of America, where it was once abundant. "The separation of the existing species in distant localities suggests that they are the remnants of an extensive group, once widely distributed" (Marsh).

The odd-and-even toed Ungulates, or the Perissodactyle and Artiodactyle groups, were the most abundant mammals in the Tertiary period, and range through all its divisions. They include a variety of fossils and some living genera as the horse and tapir among the Perissodactyles, and the Suillines of the Artiodactyles, which are considered to be the present modified representatives of a series of forms which can be traced through various changes from the Eocene upwards.†

The Hollow-horned Ruminants appear to have commenced in the Miocene, but are more fully developed in the later periods, as the Bison and Urus. The Musk-sheep, restricted now to Arctic America, was widely distributed in Post-Pliocene times over a great part of Europe and in America.

* A. R. Wallace—"Comparative Antiquity of Continents," Proc. Roy. Geogr. Soc., Vol. xxi., 1877.

† See the interesting and suggestive Address, by Prof. O. C. Marsh, "Introduction and Succession of Vertebrate Life in America," Nashville, 1877.

The Proboscidea commence in the Miocene by *Deinotherium*, and the *Mastodon*, *Stegodon*, and *Elephas* (in the Sevaliks) which latter genus, however, is not found in the Miocene of Europe or America, but is continued in Pliocene and Post-Pliocene times by the sub-genera *Loxodon* and *Euelephas*, to which the living African and Asiatic elephants belong.*

The Toxodontia, related to the Rodentia, Edentata, and Ungulata, are peculiar genera, hitherto only found fossil in the Post-Tertiary deposits of South America.

The Rodentia commenceed in the Eocene period, are fully represented in the Miocene and Pliocene strata of North America, and were as equally abundant in the Post-Tertiary of South America as they are at present.

Both Cheiroptera (as *Vespertilio*) and Insectivora occur in the Eocene, but they do not appear to be common to the later periods. Insect-eating Bats existed in the Miocene period, as also did Moles and Hedgehogs ; and in the Post-Tertiary caves of Brazil many remains of Bats have been noticed belonging to living genera of Phyllostomidæ—a family peculiar to South America.

The Carnivora range from the Eocene (as *Canis*), and the remains of numerous genera are found in the Miocene, Pliocene, and Post-Pliocene strata.

The Quadrumana are represented by several genera in the Eocene period related to the Lemurs, and their remains are found in the Miocene and later Tertiary. Remains of Monkeys are abundant in the Brazilian caves, and these belong to genera now living in South America. No remains of Old World Monkeys have been found in America.

* Prof. Marsh states with regard to the Equine sequence in the American Tertiaries, that the earliest representative of the horse is the small *Eohippus* of the Lower Eocene, which is succeeded in the Middle and Upper Eocene by *Orohippus*. In the Lower Miocene is *Mesohippus*, followed in the upper part by *Miohippus*, allied to the *Anchiterium* of Europe, and in the Lower Pliocene by the more equine *Protohippus*, which resembles the *Hipparion* of Europe, and the very equine *Pliohippus*. In the Upper Pliocene only, does the true *Equus* appear, which in the Post Tertiary roamed over the whole of North and South America, and soon after became extinct.—"Address," p. 32.

Prof. Marsh remarks, "The Himalayan deposits called Upper Miocene, and so rich in Proboscideans, indicate in their entire fauna that they are more recent than our Neobrara river beds, which, for apparently good reasons, we regard as Lower Pliocene. The latter appear to be about the same horizon as the Pikermi deposits in Greece, also regarded as Miocene." —"Address," p. 51.

This brief review of the distribution of the Animal Kingdom in geological time shows that it was not only one of progress but of gradual differentiation, and also that by the various physical changes which the earth's surface has undergone, the faunas of the later Tertiary period have become more isolated, and have differentiated in the marked geographical provinces to which I have previously alluded, in each of which the present mammalian fauna is closely related to its antecedents in the Post-Pliocene period of the same area,* and in some cases their ancestral forms may be traced still farther back in the Tertiary period, thus showing the law of the geographical succession of types which Mr. Darwin has so clearly ennunciated.†

In thus bringing before your notice some of the facts upon which our deductions must be based, I must beg you to remember that much more time than is at my disposal this evening would be required to treat of them thoroughly. Looking, however, generally at the higher forms of Vertebrata, it will be seen that most of the great Orders, with the exception of the Marsupials, commenced in the Eocene or Lower Tertiary period, in which nearly all the genera are extinct, and they have been more or less continued through various forms to the present day, where they culminate in the existing groups of mammals.

In comparing, therefore, the plant-life with that of the Invertebrata, foreshadowed slightly as each Kingdom was in the preceding period—the sudden incoming of Cryptogams and a few Gymnogens with the Palæichthic life of the Devonian and Carboniferous seas, --the marked appearance of Gymnogens (Cycads and Conifers) with the first great development of Reptile life, and the nearly contemporaneous appearance of the Dicotyledons with most of the Orders of Mammalia at the commencement of the Eocene period, is a singular and interesting fact in the succession of life on the globe. (See Plate, p. 220).

The study of the Earth's history reveals a succession of forms, whether the result of continuous evolution, of modification by

* Thus the present Marsupial fauna of Australia, the Edentate fauna of South America, were respectively represented by Marsupial and Edentate genera in the Post-Tertiary deposits of the same countries; so the wingless birds of New Zealand were preceded by gigantic forms of a similar order; and even in the Arctogæal province most of the mammalia were foreshadowed by extinct species of the same genera in the Post-Pliocene period.

† "Origin of Species," Fourth Edition, p. 406.

descent, whether by means of successive creations, or "by orderly succession and progression due to Natural Law or Secondary cause,"* or by the operation of some higher law of change and progress conjointly acting with other causes, by which the numerous forms now peopling the earth came into existence.

Whatever may be the law of that progress, there can be little doubt, when viewed rightly, that in all past times of the earth's history there has existed the same unity and order, the same balance of power, the same adaptation of organic life to the successive inorganic conditions, the same evidence of creative intelligence and design, as we see displayed throughout existing nature at the present period, and as will doubtless be continued in the future; or, as was once tersely said by Professor Phillips, "The present explains the past, and reveals the future."

ORDINARY MEETING, November 2nd, 1877.

Professor John Morris, F.G.S., &c., President, in the Chair.

The following Donations were announced:—

"Lecture on the Antiquity of Man," by Prof. T. Rupert Jones, F.R.S., 1877; from the Author.

"On the Corallian Rocks of England," by the Rev. J. F. Blake, M.A., F.G.S., and W. H. Hudleston, M.A., F.G.S., 1877; from the Authors.

"Quarterly Journal of the Geological Society of London," August, 1877; from that Society.

"Abstracts of the Proceedings of the Geological Society of London," No. 339; from that Society.

"Journal of the Quekett Microscopical Club," July, 1877; from the Club.

"Annual Report of the Committee of the Bath Royal Literary and Scientific Institution," for the year 1876; from that Institution.

"Annual Report of the Bristol Naturalists' Society," for 1876 and 1877; from that Society.

"Proceedings of the Berwickshire Naturalists' Club," Vol. viii., No. 1.

* Owen, "On the Nature of Limbs," 1849, p. 86.

"Transactions of the Edinburgh Geological Society," Vol. iii., Part 1, 1877; from that Society.

"Annual Meeting of the Leeds Philosophical and Literary Society," for 1876-77; from that Society.

"Transactions of the Manchester Geological Society," Vol. xiv., Parts 11 to 13, 1877; from that Society.

"Proceedings of the Somersetshire Archæological and Natural History Society," New Series, Vol. ii., 1877; from that Society.

"Proceedings of the South Wales Institute of Engineers," Vol. x., No. 5, 1877; from that Institute.

"Annual Report of the Warwickshire Natural History and Archæological Society," for 1876; from that Society.

"Communications to the Monthly Meetings of the Yorkshire Philosophical Society," 1876; from that Society.

"Journal of the Society of Arts," July to October, 1877; from that Society.

"Annual Report of the School of Mines, Ballarat," for 1876; from the School of Mines.

"Bernard Quaritch's General Catalogue of Books, Supplement for 1875-77;" from Mr. Quaritch.

The following were elected Members of the Association:—

John Hopwood Blake, Esq., F.G.S., Assoc. Inst. C.E., H.M. Geol. Survey; Mrs. A. Cowen; G. R. Cowen, Esq.; E. D. Duncan, Esq.; T. Richard Johnson, Esq.; Alexander Payne, Esq.; Thomas Ogier Ward, Esq., M.A.

The President then delivered the Inaugural Address of the Session 1877-78. (See page 191.)

ORDINARY MEETING, December 7th, 1877.

Henry Hicks, Esq., F.G.S., Vice-President, in the Chair.

The following Donations were announced:—

"Memoirs of the Geological Survey, Geology of East Somerset and the Bristol Coal Fields," by Horace B. Woodward, F.G.S.; from the Author.

"On the Occurrence of *Plicatula lævigata* of d'Orbigny, in the

Middle Lias of Gloucestershire," by Frederick Smithe, LL.D., F.G.S.; from the Author.

"The Quarterly Journal of the Geological Society of London," for November, 1877, No. 132; from that Society.

"Abstracts of the Proceedings of the Geological Society of London," Nos. 340 and 341; from that Society.

"List of the Members of the Geological Society of London, &c.;" from that Society.

"Proceedings of the Natural History Society of Glasgow," Vol. iii., Part 2.

"Journal of the Proceedings of the Winchester and Hampshire Scientific and Literary Society," Vol. ii., Part 3.

"Transactions of the Manchester Geological Society;" from that Society.

"The Seventh Annual Report and President's Address, 1876-7, of the Leeds Naturalists' Club and Scientific Association;" from that Club.

"Journal of the Society of Arts," Nos. 1,303-7; from that Society.

The following were elected Members of the Association:—

Dr. Drew; H. B. Lindsay, Esq.; Rev. W. E. Oliver, LL.B.

The following Paper was read:—

On The Chalk of Yorkshire.

By The Rev. J. F. Blake, M.A., F.G.S.

There are special reasons why a communication on the Chalk of Yorkshire should be addressed to the Members of the Geologists' Association. In the first place one of the earliest of their published papers, that of the Rev. T. Wiltshire, "On the Red Chalk of England," deals with one of the most interesting portions of the subject. In the second place, one of the most recent and, perhaps, the most important of the additions to our knowledge of it has been made by a French geologist—Dr. Barrois—who visited the county in company with the members of the excursion party to Yorkshire two years ago: and in the third and most important place, it is to a Member of this Association, Mr. R. Mortimer, of Fimber, who, for seventeen years, has been steadily accumulating the fossils of a Chalk reported unfossiliferous, that a very large portion of

our knowledge of its fauna is due, and who has lent me some of the most interesting of his fossils to study, as to a brother Member.

The formation I am about to describe forms a broad tract of country from the vale of Pickering on the north, where it is widest, to the Humber, where it has much less breadth—not on account of its more feeble development, but because of its stratigraphical position. It rises to its highest elevation on the western escarpment, and at about two-thirds of the whole length from the south. On this western side, which is cut into by several deep and narrow valleys, we find its base exposed, and from thence in an easterly direction it continues with a general south-easterly dip to descend in level as we rise in the geological series, till the uppermost portion is hidden beneath the Holderness Drift, and more and more so as we pass southwards, so that on the Humber none of the upper beds are visible. Its range along the south side of the vale of Pickering, in its course from Knapton to Speeton, is generally considered to be due to a change of strike, but I doubt whether there is any great change in the direction of the subsequent elevation, but prefer to believe that the boundary of the area in which the Chalk was originally laid down has here a more easterly direction. There are no indications, to my knowledge, of the Chalk having spread far in Yorkshire on the north side of the vale of Pickering, though, of course, it must have originally extended much farther than we now can see it.

The object of the present paper is, in the first place, to point out what subdivisions may be recognised in this formation, and to give some indications of the various faunas contained in them, and then to discuss some of the interesting questions which arise in course of this description.

In Professor Phillip's original description the whole of the Yorkshire Chalk was simply called "White Chalk," and no attention was paid to anything but the coast, and few fossils enumerated but those from Dane's Dyke. He noticed, however, and drew attention to the fact, that the lower or more western portion was largely supplied with flints, while the higher and more eastern, stretching through Bridlington, Driffield, and Beverley, was destitute of them And in this state of division, with the addition of the Red Chalk below, the formation has remained till very recently.

Of these three subdivisions, the Upper or Flintless Chalk had been fairly well worked at in its fossiliferous locality of Dane's Dyke

seems, too, to be wonderfully acute at finding fossils, which bristle in his lists in a marvellous way, from places which ordinary geologists would pronounce very barren ground.

Having, while resident in Yorkshire, made several miscellaneous observations on the Chalk, and being tolerably familiar with its lower portion, and feeling that it was no credit to us that that should be left for a foreigner to do that ought to have been done by ourselves, I thought it would be advisable to devote some little time to the study of this subject, to see what subdivisions could satisfactorily be made, and how far those founded on palæontology could be considered natural. The time I intended to give has been twice cut short, so that I can scarcely feel so much satisfaction in the results as I should wish, still I think I have acquired a fair idea of the sequence of the beds, and believe that future observation will do no more than fill up the details. I have also only been able to see part of Mr. Mortimer's rich collection—a complete examination of it would doubtless much enrich the fauna, but would not, I think, affect the classification.

Dr. Barrois gives the following table of the subdivisions which he recognises in Yorkshire, in descending order:—

GENERAL CLASSIFICATION.	YORKSHIRE DIVISIONS.	THICKNESSES.
Zone of Bel. mucronata ...	Wanting.	
Zone of Marsupites	Bridlington Chalk { many sponges / few sponges }	260ft.
Zone of Micraster coranguinum	Flamborough Head Chalk	97ft.
Zone of M. cortestudinarium..........	Chalk of Breil point	
Zone of Holaster planus ..	Grey Flinty Chalk of Northsea ...	97ft.
Zone of Ter^{ina} gracilis	Hessle Chalk	65ft.
Zone of Inoceramus labiatus	Hard Speeton Chalk, with red bands	45ft.
Zone of Belem. plenus	Unrecognised	40ft.
Zone of Holaster subglobosus	Speeton Chalk with red bands	
Chloritic Marl	Sponge bed in Lincolnshire.. ...	
Zone of Pecten asper	Wanting.	
Zone of A. inflatus	Red Chalk of Speeton	33ft.

This complicated classification may perhaps be valuable when the larger subdivisions are completely recognised, and we are thoroughly familiar with them; but as a plan for the study of the very poorly fossiliferous Chalk of Yorkshire, it is almost entirely practically useless. It is a classification made on French ground, applied as far as may be to another area. We must first, I think, discover the classification as suggested by the area itself, and then we may profitably compare it with the development of other areas. Although, therefore, in examining the country I have had this table in my mind, I have endeavoured, like a juryman, to gather results simply from the evidence in the case before me.

Nor do I think that the mineralogical classification by the means of the distribution of flints to be by any means neglected in the study of a local area, if we find on examination that it is sufficiently constant to be of service. This I believe to be the case with the Chalk of Yorkshire, and that it is in this area a most valuable guide.

In the descriptions of the various subdivisions it will be best perhaps to commence at the base, which contains the beds which are best known, and of the greatest interest.

It will be seen that in Dr. Barrois' classification, below the zone of *Inoceramus labiatus*—which, in spite of his declaration that it contains red beds at Speeton, may be taken as the base of the true White Chalk—five zones are set out, of which, however, three are wanting or not recognised in Yorkshire, so that we have left these two—namely, the zone of *Holaster subglobosus*, which is the Chalk with red bands at Speeton, and that of *Ammonites inflatus*, which is the true Red Chalk of Speeton. We shall find it convenient to study these two zones together.

That combined they make a well-marked subdivision was long ago noticed by Young and Bird in the following words (abbreviated):—"The bottom of the cliff [at Speeton] is found to consist of another species of chalk which we may call the LOWER or COLOURED CHALK. This portion of the Chalk has the same grain and fracture with the great body of the Chalk; but it lies in horizontal strata of no great thickness, yet tolerably compact, and instead of a bright white colour the greater part is of a dull white with a greenish and in some places a blueish tinge, while other parts are of a brick-red colour, or rather of a duller red approaching to chocolate colour. The Red Chalk alternates with the dull white in large stripes; the dull white chalk grows darker

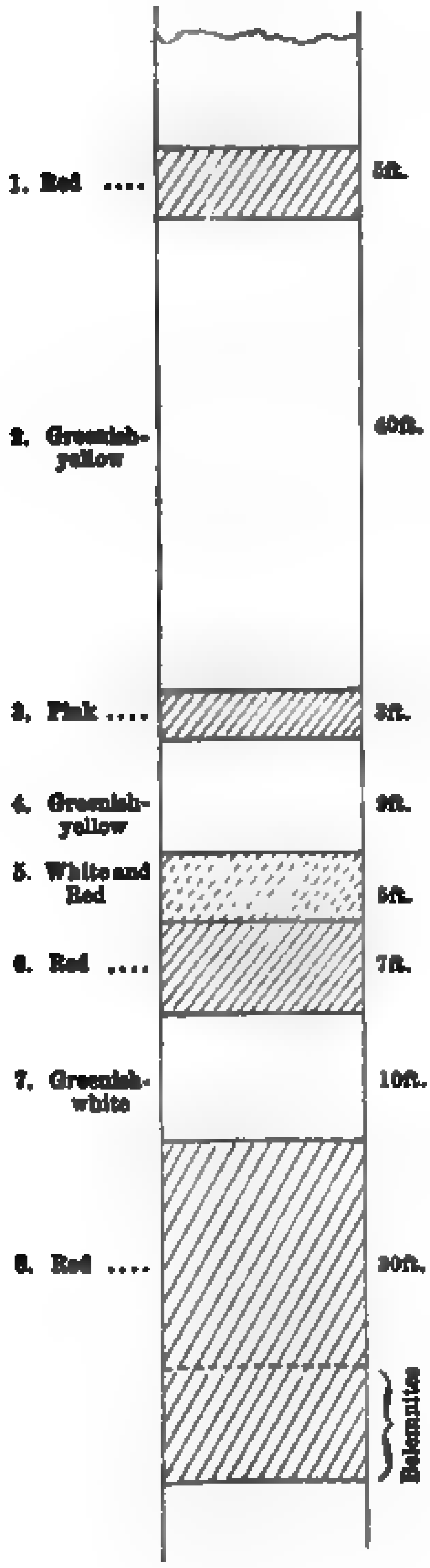
as it descends, passing into a greenish or blueish grey. The thickness of the coloured chalk bears but a small proportion to the great mass of the chalk rocks, and it approximates in softness and other qualities to the shale upon which it reposes. This chalk therefore, does not correspond with what is called the Lower Chalk in the Southern Counties, for the latter is of a hard quality; but it does not appear to differ much from the argillaceous chalk or Chalk Marl found below the hard chalk in these counties." "The nodules and cakes of flint do not occur in the coloured chalk." These remarkably accurate observations must surely have been overlooked by those who imagined there was but *one* red chalk at Speeton, or who supposed that the Chalk was flint-bearing to its base. Indeed, seeing that the zone of *Holaster subglobosus* is now in part identified on palæontological grounds with the Chalk Marl, the correlation of these Yorkshire beds with the latter was remarkably near the truth.

The whole series, characterised by the entire absence of flints, the peculiar lithological character to be presently noted, the tendency to colour and the abundance of fossils is best seen in the cliffs of Speeton, where, however, they are exceptionally developed. Only one real description of these beds—that of Mr. Wiltshire in the volumes of the Palæontographical Society—has ever been given, though this has been partially repeated in Professor Phillips' new edition of the "Geology of Yorkshire," most observers having contented themselves with what may be seen in the broken declivities of Speeton gap. Here the beds are in such wild confusion that no one with better opportunities at hand should take any notice of them. Such opportunities are to be had about a mile and a half further on towards the chalk cliff; and it is here that Mr. Wiltshire's section was drawn. The clearness of the section here exposed will be obvious by a comparison of his and my own independent account of it, which I place side by side, because a point of discussion will arise with reference to the base.

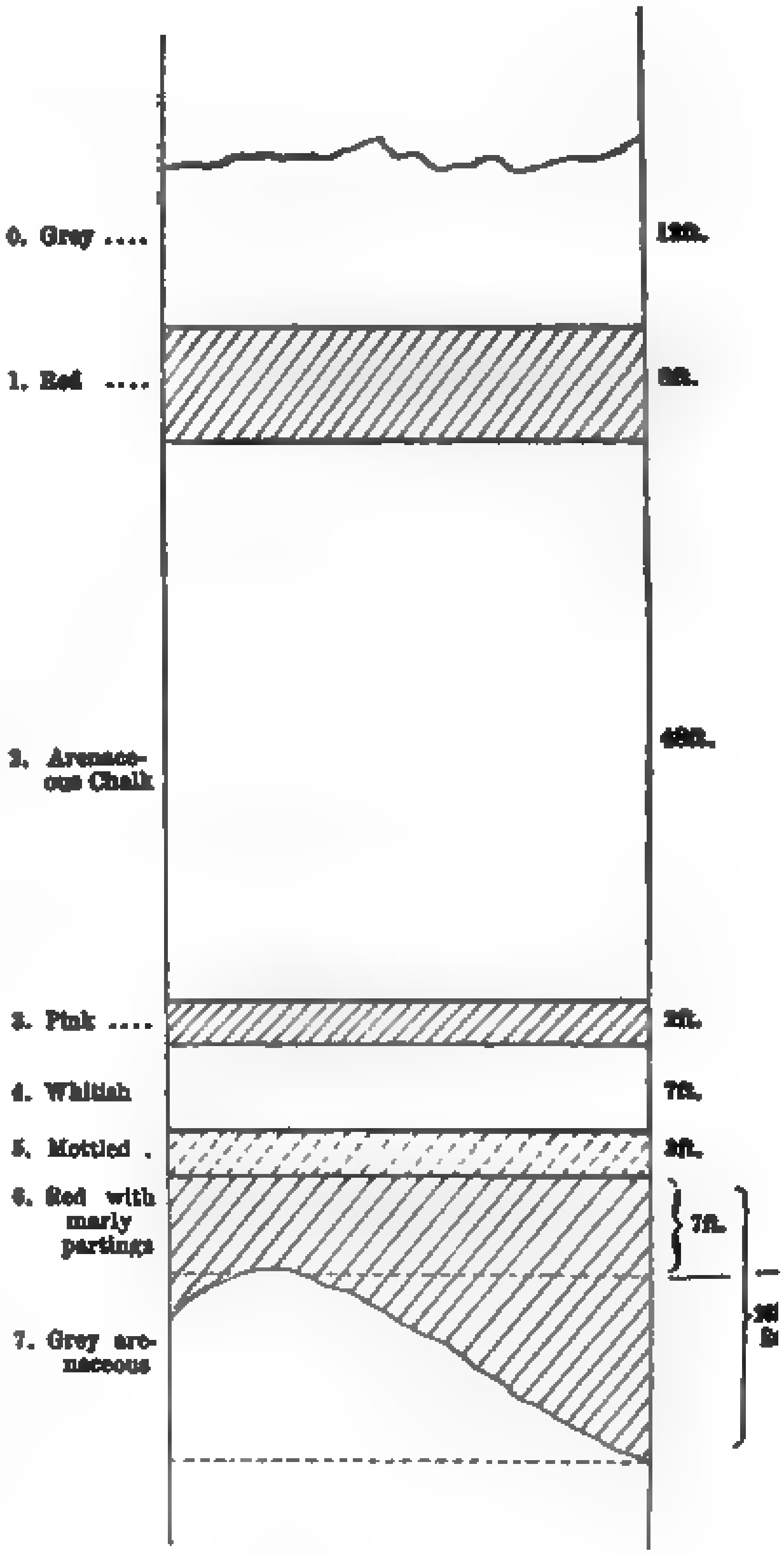
The cliff here about has a height of nearly 400 feet, of which the upper 250 feet and more are occupied with flinty chalk belonging to higher zones; but as the flints come on gradually, it is of course rather difficult to say exactly where one ought to commence the lower series. We have no reason, however, to suppose that the highest red bed is the limit, but may take in some of the overlying chalk which has the same character as that below. Our comparative sections will then stand as follows :—

FIG. 1.—SECTION OF THE BASE OF THE CHALK IN SPEETON CLIFF.

1.—BY MR. WILTSHIRE.



2.—BY MR. BLAKE.



The beds above No. 5, which will be presently discussed, show a remarkable agreement; but that is not the case with the beds below. There is, indeed, a clear cliff section of some length (accounting for minor variations in the upper beds), the base of which as it rises to the north-west exposes the red bed (No. 6), and its underlying grey beds (No. 7) at the last point before it is obscured by the abundant *débris* that has fallen from the cliff.

Further to the north-west, *i.e.*, on the rise, are exposed two masses of red marly chalk, thicker than any yet seen, having a maximum, according to my measurement, of 26 feet. This represents the true Red Chalk of Mr. Wiltshire—No. 8 of his section—the "Hunstanton Limestone" of Professor Judd's section [it is not much of a limestone here]. It is placed by Mr. Wiltshire as *underlying* his bed No. 7 of "greenish-white chalk." But my examination of the locality has led me to come to another conclusion, which I hold to be more probable, though not absolutely proved.

The grey arenaceous bed (No. 7) is a very peculiar one, though its characters are in a less degree imitated throughout the upper beds of this lower part of the Chalk both in Yorkshire and elsewhere. It is an extreme variety of nodular chalk. The rock is composed of a number of lenticular masses, two or three inches in diameter—one might almost call them concretions—which lie packed together like so many flattened potatoes, separated by bands of more argillaceous matter of varying thickness, but mostly about half an inch, the limits, of course, between the nodules and the matrix being ill-defined.* I have called it chalk, but it has a very different appearance—almost mocking a calcareous variety of the Upper Greensand—of which, without possessing its peculiar fauna, it appears to be somewhat the representative, *i.e.*, by marking a very shallow water arenaceous deposit previous to the Chalk Marl. In this respect it seems to me to be exceedingly interesting, and I have roughly analysed it to ascertain its proportion of sand and clay. There appears to be as much as 13 per cent. of insoluble matter, while the alumina, iron, &c., in the soluble portion being 12 per cent., only 75 per cent. is left as a maximum for true calcareous matter.

Now the *general character* of this bed is continued into the red

* There are some beautiful crystals of iron pyrites in this bed in the form of truncated octohedra.

bed above it, while the nodules have become more calcareous, and the intervening matrix more argillaceous and thicker; but what is more remarkable and perfectly certain is that the red colour *does not go with the stratification*, but has an undulating boundary, cutting across the beds obliquely as in the following diagram.

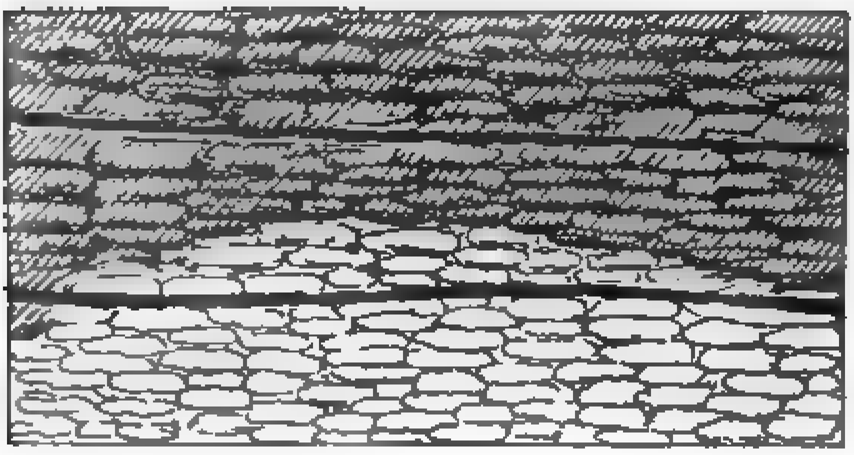


FIG. 2—JUNCTION OF RED AND GREY BEDS AT SPEETON.

Nothing could be a more perfect proof that the red colour is a subsequent introduction to the formation of the beds, and it shows that as far as mineral composition or position goes, there is nothing to prevent the whole of the grey beds becoming red at some further distance, should they become more argillaceous.

It is my idea, therefore, that the great mass of 26 feet of red chalk further to the north-west is nothing but beds No. 6 and 7, become perfectly red and at the same time more argillaceous. The reasons for this are as follow:—1st, from the stratigraphy. The position of this mass of red chalk is so high above the shore that there is not room, without an extraordinary change of dip, for the grey arenaceous beds on the shore to surmount it in so short a distance; and, moreover, the beds which do overlie it have scarcely the same arenaceous character as No. 7, but are far more like No. 5. The uppermost four feet are a pure marl, most like the enlargement of the partings of the bed No. 6. It was these facts which led me on the spot to this idea, and not from any preconceived notions. But there are some palæontological facts which are equally curious. The common fossils of the Red Chalk No. 6, or lowest bed of "false red chalk," are the exact counterpart of those of the "true red chalk," with one remarkable exception, viz., the total absence of the little Belemnites in the former. At least I spent an hour on one occasion looking for nothing else, and

half an hour on another without finding any, and they are plentiful in the chalk below. Now what does Mr. Wiltshire say of the latter?—"In its uppermost portion very large Terebratulæ may be obtained, and generally many of an ordinary size; and at about 20 *feet below its commencement* Belemnites, &c., occur." So that they are confined to the base, where alone also I could find them, and the uppermost part is without them. In the grey beds (No. 7) I found several large *Terebratulæ biplicatæ*, and, what is more remarkable, the *Belemnites minimus*, showing it to correspond with the lower portion of the Red Chalk. That, then, is my reading of the section; and I seem to learn from it—1st, that the local development of red beds is not so thick by 30 feet as supposed; 2nd, that part of the great mass of red chalk at this spot belongs to the zone above, and must not be included in the palæontological zone of *Belemnite sminimus*; and, 3rdly, that this thickness of red beds, said to be 30 feet, does not extend so much as a quarter of a mile to the south-east.

The true Red Chalk is called by Dr. Barrois and others the zone of *Ammonites inflatus*. That fossil, under the name of *Ammonites rostratus* is certainly recorded by Mr. Wiltshire* as occurring rarely at Hunstanton, but it is not recorded by Professor Judd as found in Lincolnshire, nor am I aware that it has ever been found in Yorkshire; so that as a guide shell it is absolutely useless. Whereas *Belemnites minimus* is universally characteristic of the deposit, and I would propose that it should rather be characterised by that fossil. Indeed the *Ammonites rostratus* is supposed to belong to the Upper Gault only, while the true Red Chalk must represent the whole of it, and would therefore more truly be associated with the Belemnite which passes from the bottom to the top of the Gault.†

A few words about the upper part of the Speeton section and we must leave it. Throughout, the beds are nodular, with interstratified clay, but they become more like ordinary chalk as we ascend. Not a flint is anywhere to be seen, and the colour is

* Quart. Journ. Geol. Soc., Vol. 25, p. 188.

† That the Red Chalk represents not the upper part only but the *whole* of the Gault (and more), is also shown by its containing *Ammonites auritus* commonly at Hunstanton; and, as I can bear witness, in Lincolnshire also, which fossil is confined to the *Lower* Gault at Folkestone. I once stated (Yorksh. Nat. Club Proc., 1869) that I thought it of Upper Greensand age, but that was rather with reference to the *Cambridge* Greensand, whose fossils have now been proved to have been largely derived from the Gault.

greenish-grey. The best denomination, therefore, for it, in spite of the occurrence of red bands, is "the Grey Chalk." It is one of the fossiliferous zones of the series; and the urchin known as *Holaster subglobosus* being tolerably abundant, it may well bear the name of this characteristic fossil. One of the most characteristic species of both zones is the little *Avicula gryphæoides*, which is very abundant. Nor are the small form of *Terebratula semiglobosa* and the *Kingena lima*, which is very like it, much less common in both zones. It is by the rarer fossils that they are to be chiefly distinguished. From the zone of *Belemnites minimus*, Dr. Barrois quotes 15 species, of which the most interesting are the *Terebratula capillata*—a beautifully ornamented species tolerably common at Hunstanton, but not before noted at Speeton—and the *Cidaris Gaultina*. Mr. Meyer* also records the occurrence of *Inoceramus sulcatus*—a truly Gault species—and in Mr. Mortimer's collection is an Inoceramus, which is probably *I. tenuis* common at Hunstanton, and also recorded from Speeton by Dr. Barrois. I have also met with a Ventriculite similar to those which occur at Hunstanton, but which I do not venture to name.

In the higher zone, the *Discoidea cylindrica* seems to be common, though I have not met with it; and the very remarkable form of *Cardiaster*, prolonged to a beak on the upper part of its test, described by Professor Forbes as *C. rostratus*, occurs here and also in higher beds.

I do not attempt to give a complete list of the fossils of any of these subdivisions, as the time has not yet come for it—probably a more complete examination of Mr. Mortimer's collection would greatly add to them.

But we must now leave Speeton and pass inland, and we shall find that the study of the base of the Chalk leads us to several very interesting facts.

It is well known to every one that the Cretaceous rocks in Yorkshire are not conformable to the rocks below them, but lie on their denuded edges. They were so represented by Professor Phillips in 1858,† but the section which he drew (diagrammatic no doubt) represented the surface of the older rocks as planed off horizontally, and perhaps that is the idea which still prevails. If, however, we follow the line of junction between the Cretaceous

* Geol. Mag., Vol. vi., p. 13.

† Quart. Journ. Geol. Soc, Vol. xiv., Pl. vi.

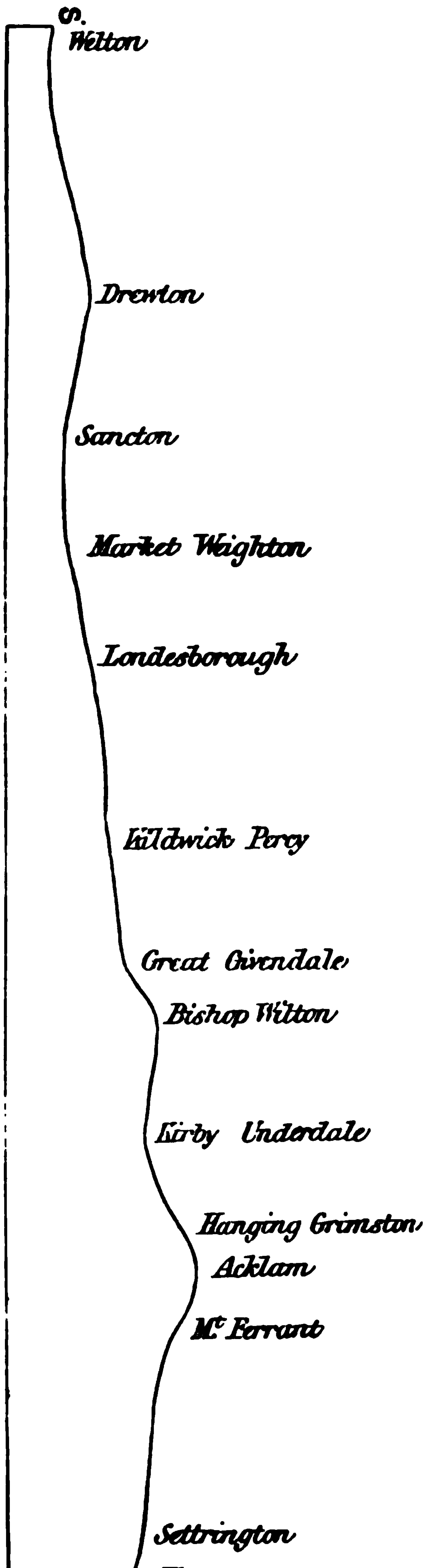


FIG. 8.—FORM OF THE SURFACE ON WHICH THE CHALK OF YORKSHIRE IS DEPOSITED.
Horizontal Scale 5 miles to the inch. Vertical Scale 1 inch to 720 feet.

strata and those below them—a task rendered easier by the red colouring at that part of the series—we shall find that it is by no means level, but rises from 150 feet at the south in an irregular manner till it reaches a level of 575 feet near Acklam, from whence it descends again to 350 feet at Thorpe Basset, and that in this course there are minor undulations, as is represented in the accompanying diagram. It is of less interest to trace the outcrop from Thorpe Basset eastwards to Hunmanby and Speeton, as we know that we are not nearly following the line of strike. One result of this is that instead of the Red Chalk gradually diminishing from 30 feet at Speeton to four feet at Hunmanby, as supposed by Professor Judd and repeated by Dr. Barrois, it is of any or no thickness even in Yorkshire, according as it lies on the vallies or hills beneath, and, indeed (except in a few localities) from four to six feet would be a very fair allowance for its average thickness. Another result is that

the Chalk a number of little patches of local deposits representing some of the intermediate time between it and the general basis on which it rests. We might even reckon the great development of the Neocomian and Portlandian beds at Speeton as one of these local patches laid bare, but that it is seen farther away from the real outcrop of the Chalk than any of the others, and rather exposed on the dip.

In describing the development of the Red Chalk along the outcrop, it will be well not to omit the few scattered localities along the east and west range from Thorpe Basset, though I shall say but little of them. The whole hill side is in general covered by the *débris* of the higher beds, which have slipped down from their places sometimes in such large masses as to be very deceptive, and it is only a chance excavation by some stream or artificial work that reveals the true position of the base with its coloured chalk. The first exposure nearest to Hunmanby going west is at a small spring near the road at Bennington, where the Red Chalk, with its characteristic fossils, is seen beneath the alluvial soil at a height of about 180 feet above Ordnance datum. And it is in the picturesque neighbourhood of Ganton, quite close to this, that a geologist would see at once his best chance of an exposure, nor would he be disappointed. In the fine coomb on the west of Ganton Hall the Red Chalk is well seen at the copious springs and spreading over a considerable surface of the ground, and above it the rapid slopes of the hill sides expose more or less the overlying chalk as far as the zone of *Inoceramus mytiloides*. At Potters Brompton, close in the neighbourhood, is an old pit, in what is probably Neocomian clay, where as much as ten feet of Red Chalk is exposed. It seems here to be very fossiliferous, and from the abundance of fragments of large *Terebratula biplicata*, which lie scattered about, would probably repay a fossil collecting visit. As these beds are not above the 200 feet contour line, and the *Inoceramus mytiloides* beds are at 450 feet, there must be as great a development here of the lower portion of the Chalk as at Speeton. West of this point there is nothing to be seen *in situ*, except some of the red-coloured upper beds of the Grey Chalk, which are well exposed, and quite characteristic along the roadside leading down the hill to West Heslerton.

In its range from North to South, as indicated by the diagram

we first have a chance of finding it on the heights above Settrington, called the "Whams." Here, however, it is absent. The clays and doggers, with *Ammonites alternans*, of the Kimmeridge Clay, on the sloping hill side, lie immediately beneath the flint-bearing chalk of a higher zone, and not a fragment of Red Chalk is to be seen, as noticed of this very neighbourhood by Young and Bird. Mr. Mortimer, indeed, has shown me a Red Chalk fossil, said to have come from Settrington Wold House, where also I could find none; but the evidence at the Whams is, to my mind, incontrovertible that the stratum is discontinuous, or if not absolutely so, of indefinite thinness.

In the narrow valley in which runs the railway from Malton to Driffield, the Red Chalk is seen very clearly lying on the Kimmeridge Clay, and the Grey Chalk, or zone of *Holaster subglobosus*, is well developed at the north of the Burdale tunnel. This valley is remarkable for the long tongue which it forms in the surface exposure of the Kimmeridge Clay, which runs in a narrow space, bounded on both sides by chalk for a distance of about three miles, and it is continued for another three-quarters of a mile, at so slight a depth below the surface, that the greater part of the Burdale tunnel is excavated through it. This alone shows the great irregularity of the older surface ; in this case we are nearly opposite the most elevated point, as shown in the diagram, near Acklam.

A section formed by a stream excavating a road on the east side of Wharram Station is here very instructive.

SECTION NEAR WHARRAM STATION.

1. Flintless Chalk, with *Holaster subglobosus*, and *Terebratula semiglobosa* . . . . . . 20 ft. +
2. Yellow, reddish Chalk, with rounded quartz grains, most calcareous towards the top, and becoming argillaceous below, with *Belemnites minimus* and *Terebratula biplicata* . . . . . . 2 ft.
3. Dark ferruginous Grit, becoming yellow and argillaceous above, passing into No. 2. . . 1½ ft.
4. Black Kimmeridge Clay with doggers, with a marked junction with the overlying beds.

Here we learn, at one view, that the "Red Chalk" is not always

red, but sometimes yellow; that it is in insignificant thickness, but yet perfectly characterised; and we find in the ferruginous grit one of those puzzling patches, which may be of any age between the Kimmeridge Clay and the Chalk. In this instance we are reminded of a similar bed, more largely developed, the occurrence of which, at Kirby Underdale, some four miles to the south of this, I noticed in the "Geological Magazine" for 1874 (page 362). It there lies on the Lias.* Its continuance to Wharram, of diminished size, but of similar character, is another argument for its belonging to the Cretaceous, and not to the Oolitic series. Unfortunately, it is not a rock in which one could look for fossils with any hope of success, but it must be at least newer than the Kimmeridge Clay. Can it, by any possibility, be a representative of the Middle Neocomian Ironsands, which, in Lincolnshire, overlie the Tealby Series, and have a thickness, according to Prof. Judd, of about 60 ft.?

The rock of Kirby Underdale, where it is 20 feet in thickness, is not very uniform in character. Some parts of it consist of grains of sand of very variable size, from $\frac{1}{1000}$ to $\frac{1}{10}$ of an inch in diameter, all cemented together by ferrous carbonate or ferric oxide, according to its state of exposure. A comparison of these portions with a specimen from Lincolnshire, immediately underlying the Red Chalk to the west of Louth, shows that they are very similar rocks, only the grains of sand in the latter are usually finer. Another more interesting variety of the Kirby Underdale stone consists of numerous flattened granules, such as are so common in oolitic ironstones; these make up a large portion of the stone, but are mixed here and there with large sand grains, all of them being separated by a sensible fraction of their diameter, sometimes amounting to one-half, by the dark blue-green ferruginous matrix. These portions doubtless are the richest in iron, but it does not appear to be of a suitable character for working. A third variety is very finely granular, and looks less sandy, but it

* I would take this opportunity of correcting an error in the geological map of "The Yorkshire Lias." The shales at this point are coloured as Oolitic, as there are undoubted Oolitic Shales in the same valley. They were not Middle Lias, and I could find no fossils in them. Since that time I have found jet-rock ammonites in them. So they should be coloured Upper Lias; and, as there is no Upper Lias known within five and eight miles respectively on either side, this is another instance of an isolated patch discovered by denudation.

contains, notwithstanding, nearly 40 per cent. of insoluble matter. On the whole, then, though the oolitic portion is peculiar, but might, on the supposition made, result from the mingling of the oolitic ironstone with the ferruginous sands of Lincolnshire, the similarity of this rock with the last-named sands is fairly established, and it may, perchance, represent them.

If such a correlation were a possible one, we might expect to find the Neocomian oolitic Ironstone somewhere about here to the west, as the beds are dipping east—say at Acklam. Now, in a small chalk quarry on the hill, called Greets Hill, just to the east of that village, is another instructive section:—

SECTION AT GREETS HILL LOWER QUARRY.

1. Grey spongy Chalk without flints, and containing *Holaster subglobosus*, *Terebratula biplicata*, and *T. semiglobosa*, small var. . . . . . 16 ft.+
2. Rubbly Red Chalk, containing masses of dark-brown oolitic ironstone imbedded in it, also *Belemnites minimus* . . . . 2 to 3 ft.
3. Dark hard (? Kimmeridge) Clay.

Here then, in a *remanié* form, bouldered in the Red Chalk, we may have what we are looking for; a comparison of this oolitic ironstone with that from near Tealby shows them to be remarkably similar. They both consist of a light-brown ferruginous matrix, of a uniform soft appearance, with scattered oolitic grains of a darker colour, shining in appearance, and of small size.

Unfortunately when I was at Acklam, I had not conceived the idea of what these beds might be, so clearly as now, or I would have devoted longer time to looking for fossils in them.

I leave, therefore, this bold guess unproved, and shall not, therefore, undertake to explain how the Lincolnshire type of Neocomian Beds could come so close to the Speeton with so little change.

Some very interesting fossils are in Mr. Mortimer's possession from this neighbourhood and from that rich, but unfortunately very inaccessible hunting-ground in Garrowby Park. Among the Cephalopods is an ammonite of 6in. diam., not well preserved, and most like *Am. peramplus*, which is interesting as being the only ammonite known in the Red Chalk of Yorkshire. There is also

a nautilus, from Mount Ferrant, probably *Nautilus Bouchardianus.* Of other molluscs, the most interesting are *Plicatula pectinoides*, a well-known fossil in the southern Gault, and occurring at Hunstanton (in my collection), and two *Rhynchonellæ*, *R. latissima*,* and another, which seems to be *Rhyn. Wiestii*, found in the Chloritic Marl of Chardstock and Beer. I may also mention *Terebratula capillata*, already recorded by me, and *T. sulcifera* (?). There are also two Echinoderms of interest—the common rough-stemmed crinoid of Hunstanton—*Bourgueticrinus rugosus*, and a smooth allied species; and not far south from here was found *Holaster suborbicularis*, also a characteristic fossil elsewhere.

This district, especially the north end of Burdale tunnel has also been fruitful in fossils of the Grey Chalk, or zone of *Holaster subglobosus.* In addition to that ubiquitous echinoderm, a well-chosen guide fossil, are found, the same ammonite (better characterised) and nautilus as in the Red Chalk, *Rhynchonella lineolata*, *Discoidea cylindrica*, and a large conical *Holaster*, like that figured by D'Orbigny as *H. integer*.

Passing now to the south we come to Great Givendale, the section at which place I have already noticed in the "Geological Magazine." I have, however, a correction to make. The Ammonite found there, which I took to be *Am. Deshayesi*, the nearest Cretaceous form to it, turns out to be a fragment of *Ammonites Kœnigi*, of the Kelloway Rock, and the sands which lie beneath the Red Chalk belong to that formation, having here and there nodules full of *Ammonites calloviensis* and *Kœnigi*, some of which have been broken up and rolled about in the Red Chalk sea, till their crevices are all filled with the latter matrix—hence the deception. The underlying rock, both here and at Garrowby, is Callovian, the latter containing large *Gryphœ dilatatœ*. We may compare this section, with profit, with that at Greets Hill—both of them being repositories of formations partly worn away.

At Millington-dale we find a very instructive exposure of the true Red Chalk at the Springs, and of the coloured bands of the Grey Chalk at a section a little further up, showing the constancy of these features, which, indeed, may be easily traced by Warter to Goodmanham, where they are well shown in the railway cutting. Between the Red Chalk and the Lias at Millington, there is also a

* Indistinguishable from the Faringdon species.

rock of which I can make nothing; it may turn out to be another patch. On the rest of the range I have nothing interesting to add. The Red Chalk, on the whole, is seldom more than four or five feet thick, and the zone above, though much more considerable, cannot easily be estimated. They may be seen in many places, as far south as Welton, where they form a good base line to start from in a study of the higher members of the series. In some parts the Red Chalk is exceedingly ferruginous, as at Goodmanham, large, concentrically-formed nodules of almost pure ferric oxide, crowding together in the rock.

One or two additional fossils have occurred in the southern portion of the zone of *Holaster subglobosus*, the principal of which are *Pseudodiadema ornatum*, which belongs to the Grey Chalk of Folkestone and elsewhere, and a beautiful radiated Polyzoon, forming a new species of *Actinopora*, shaped like an inverted eight-leaved calyx, with a short stalk, and which I therefore propose to call *Actinopora calyx*.

What I have already said concludes the easiest, and I fear, the most interesting portion of our study of the Yorkshire Chalk. The subdivision of the flint-bearing beds, which indeed constitute the largest and most important part of the area, but which are so far less plentifully supplied with distinctive fossils that they have been pronounced barren, is a far more difficult matter. Even the presence in greater or less abundance of the flints, and the varying physical structure of the chalk is hard to judge of. Recurring to Dr. Barrois' table, we see that he makes no less than five subdivisions, but I do not think they are sufficiently marked in their characters to be of use as they stand.

If one could walk along the shore at the base of the Speeton cliffs to Flamborough, and examine in succession the beds as they rise, we might obtain in one view the development and thickness of the subdivisions, but that is impossible—the sea in several places washing the almost vertical cliffs, so that we are forced to do without this key in unravelling the succession inland. Fortunately, the openings for chalk-pits are in most parts very numerous, and though it is wearisome to go into one after another without finding anything but three, perhaps, of the commonest fossils, the general character of the succession becomes impressed upon one by degrees. There is some little difficulty in the matter, how-

ever, as the slope of the country has the same general direction as the dip of the Chalk, and, as one or other of these becomes greatest, do we get lower or higher beds on the surface. From a study of a large number of localities (not, I fear, sufficiently prolonged for palæontological purposes), I think myself safe in saying that the distribution of flint in the Chalk is sufficiently constant throughout the area to serve as a guide in the subdivision of the rocks, and while adopting palæontological zones, I will endeavour to indicate how they may be recognised almost without the aid of fossils.

In the lower portion of the flint-bearing series, the flints come on very gradually, and instead of being in layers, or tabular, they stand, as it were, upright in the rock, the longer diameters having a more constantly vertical direction ; and they are of irregular shapes and of small size. So inconspicuous are they, that a superficial observer might think there were none. Beds of this character may be seen nearest the bottom all round the escarpment, as towards the top of the cliff at Speeton, through 100 feet at Ganton, by Sherburn, Thorpe Basset, Wharram, Acklam, Londesborough, Goodmanham, Drewton and Melton. At the latter place, its relation to the zone below is especially clear, because we can study a quarry not 300 yards distant, but at 100 ft. higher level than the Red Chalk. Near here, also, in another quarry, called the "Greystones Pit," near the turning to Swanland, and also at Londesborough, is an interesting stratum, which I may call the "fish-bed." It is a dark, laminated clay, in some parts filled with decayed vegetable remains, and in other parts containing numerous large cycloid scales, and some small fish vertebræ. It passes gradually into the chalk above and below it, but may be reckoned as about a foot in thickness. The chalk which lies beneath it is yellowish, and contains no flints in 20 ft., that which lies above it contains a very few of the character just described, and also *Inoceramus Cuvieri*. So that this fish-bed is a sort of line of junction between the Grey and the White Chalk.

Where this lowest portion of the White Chalk has not been much weathered, as along the northern outcrop—especially beneath Thorpe Basset brow—it forms a very beautiful creamy limestone, which is used for mending the roads, but which takes a sufficient polish to render it ornamental if cut. It is thus very completely

marked in character, though it is approached by some of the beds far above it.

Three fossils are everywhere abundant in it, namely, the *Inoceramus Cuvieri*, *Rhynchonella Cuvieri*, a fine-ribbed species, always beautifully preserved, and the same *Terebratula*, or one very nearly allied to it, which occurs so abundantly in the zones below, and is quoted as *Ter. semiglobosa*, but which is, I think, much more like *T. carnea*, if it be not distinct from both.

Before going further, it will be well to say a word or two about the *Inocerami*. In reading Dr. Barrois' account, it always struck me as strange that he should have met with what he calls *Inoceramus labiatus*, so frequently, but it now appears obvious that he means, by that name, *Inoceramus Cuvieri*, for the latter is so common that he could not fail to have seen it, and yet the only one mentioned anywhere is the former. I protest, by the way, against the use of the name *labiatus* at all. Brongniart, who invented it, distinctly referred in his description to Mantell's species, *In. mytiloides*, but as he felt doubtful whether it was an *Inoceramus*, he proposed to call it *Mytiloides labiatus;* there can be no doubt, therefore, about the priority. *Inoceramus mytiloides* is a very well-marked shell, being elongated and flattened, and its ridges forming a very acute curve, easily distinguished from *Inoceramus Cuvieri*, which is much more common, and has a wider range. This is the ordinary inflated species, with strong ridges, covered with concentric lines. The *In. Brongniarti*, which occurs but rarely at this low level, but more plentifully above, is a broader, squarer shell, with rougher ridges, and often having its wide hinge preserved. There are two other somewhat rarer and very remarkable species in the White Chalk of Yorkshire, but both at a higher level, viz., the *Inoceramus involutus*, like two nautili, with their mouths opposed, and *I. digitatus*, which has rounded longitudinal, instead of, or in addition to, transverse ribs; looking like a number of fingers. There is also a broad species, which is probably new, and Dr. Barrois records from the higher beds a numerous-ribbed species, *I. lingua*, which I am not sure that I have met with, unless it be some in flint from Millington and Callis Wold, in Mr. Mortimer's collection.

But to return to the Chalk itself. This lowest zone has impressed itself on my mind as the creamy chalk, or Chalk with nodular flints, and, if we wanted a guide fossil, the *Rhynchonella Cuvieri* would be

decidedly the best. There is one important quarry about which I do not feel certain, but I think it belongs to this horizon, I mean that at Hessle. It has been described by Dr. Barrois as representing three zones, namely, those of *In. labiatus*, *Terebratulina gracilis*, and *Holaster planus*. There are three distinct bands in it, known to the workmen and quarried for different purposes. The lowest bed is worked for whiting, as it is entirely free from flints, except thin layers between the great beds. It is this that produces the great number of shark's teeth (*Ptychodus mammillaris*), for which the quarry is noted, and it also contains *Inoceramus Cuvieri*. Next above this is the "road stone," only used for that purpose on account of the nodular flints which it contains. Its fossils, as noted by me, are *Terebratulina gracilis* and *Echinoconus subrotundus*, and others are noted by Dr. Barrois. The top is the "limestone," which is burnt. This has flints in bands, but at wide intervals. These characters seem to point to the lower portion of the series, and to make the quarry a rather more flintless one than usual, in spite of the occurrence of *Terebratulina gracilis*. It is overlaid, some height further up, by the Chalk with thick-bedded flints, to be noticed hereafter. The occurrence of the fish remains associated with the same echinoderm and brachiopod, as at Folkestone, on about the same horizon, is well worthy of notice. I have not met with *Inoceramus mytiloides* from this quarry, but should expect to find it towards the top. Some teeth of *Ptychodus*, from Aldro', near Levening, must, from the locality, have come from beds about the same horizon as this Hessle chalk, if we consider it low in the series; and Mr. Mortimer has sent me recently a coprolite, without locality, which will be especially interesting if it turns out to be from this horizon.

The nature of the beds which succeed the Creamy Chalk in an ascending order is rather hard to define, their characters not being very marked. In some places, however, this portion of the series is remarkable for the thin plates into which the chalk is divided on weathering, so that the fragments are all flat. This character is put on to a certain degree, but not so completely as here, by other portions of the series, so as to be somewhat deceptive. I have called it the "slaty chalk." We can see this very well exhibited at the Speeton, or, perhaps one ought to say, Buckton cliffs, where the Chalk with nodular flints, succeeds the grey, and the whole is

capped with this slaty chalk. The last, however, runs out, before one can reach it *in situ*, but great blocks of it fall down, some of which are crowded on their surface with the true *Inoceramus mytiloides*. A better place is at Thornwick Bay, near Flamborough. Here the lower beds seem to have already changed from the nodular-flint character to the Chalk with far-separated tabular flints, which may be considered the ordinary structure of this part of the series, but the upper part is extremely flaggy, and is overlaid further along the coast by the thick-bedded flints. The same slaty character may also be observed very well in the road between Sherburn and Weaverthorpe, at a spot to be noticed hereafter, associated with more flint, and at a higher level than the Chalk with nodular flints; also between Burdale and Fimber, above the Millington Springs, and along the railway line between Market Weighton and Cherry Burton, so that the feature, though by no means constant, is widely spread. In other places the old arrangement of nodular flints seems continued to a higher level, and tabular flints in no great number succeed. Thus at Ganton, from the contour line of 400 feet to 520 feet, which is at the top of the hill, nothing but splintery chalk, with few and irregular flints, is seen, overlying the more nodular flinted chalk, and in this portion (*viz.*, at 450 feet), as before mentioned, *Inoceramus mytiloides* is abundant.

It is thus in this portion of the series only that the latter fossil is at all common. The other fossils of the beds below continue here, but become more rare, while the *Inoceramus mytiloides* is not absolutely confined to these, but occurs sparingly lower down, so that no palæontological separation can well be made, and we may call all hitherto described above the Grey Chalk the zone of *Inoceramus mytiloides*.

Some fossils in Mr. Mortimer's collection, which come from this part of the series, as *Spondylus fimbriatus*, in flint from near Millington, and *Ventriculites simplex*, are all the additional forms that I can record from this zone, with one very interesting exception, that of *Salenia granulosa*, hitherto found only in the hard white Lower Chalk of the Folkestone district, of which I have met with a well-marked test near Sherburn.

If, however, what I have just described is poorly fossiliferous, still more so is the part which lies above it. Here we have a maximum of siliceous matter, the flints lying in great tabular

masses, with irregular surfaces, and not separated by any great interval. This is most characteristically seen in the northern part of the area, between Flixton and Hunmanby, where vast quantities of flint, lying in beds, with perfectly flat surfaces, and beautifully banded within, are extracted for road metal. A little further to the east the siliceous matter seems to have encroached downwards, the slaty beds between Sherburn and Weaverthorpe being more than usually flinty. At a quarry on the top of the Wolds, called "Settrington High-street," almost the greater portion of the whole rock is composed of banded flints, all of them, as elsewhere, having a peculiar rectangular aspect and fracture, and every sign of a fossil obliterated. The same great development of flint at about the same geological level, may be seen at the top of the Burdale tunnel. As one goes down the hill towards Fimber, the less flinty chalk comes on with its usual fossils, and there again, to the east, we reach the higher beds, closely associated with the slaty chalk. We may identify the same beds in their usual place in the gorge between Millington and Huggate, opened here and there for chalk, in the railway cuttings near Cherry Burton, and in the extreme south between Welton and Hessle. The beds here, however, are not nearly so well-marked as more to the north, but have rather a character of their own, as shown in a section at Swanland Mill, and repeated in the Town quarry, Hessle, as follows :—

SECTION IN SWANLAND MILL PIT.

1. Brittle Chalk, in thin beds, and numerous bands of thin flint	14 ft.+
2. White Chalk, with four thin flint bands . .	14 ft.
Terebratula semiglobosa.	
3. Continuous doggery flint, very continuous, not flaggy, but banded towards the outside . .	1 ft.+
Ananchytes ovatus, and *In. Cuvieri.*	
4. Chalk, becoming more flaggy and argillaceous below, till it becomes almost a shale . . .	6 ft.
5. Ordinary Chalk, with flint bands from 6-8 in. every 2 ft.	6 ft.+

These generally unfossiliferous masses, containing, however, a

species of *Micraster* at Millington Lane, in addition to those mentioned, and a laced ventriculite near Hunmanby, form a good band of separation between the more fossiliferous zones above and below; and if called upon to characterise it palæontologically, I should prefer to call it "the barren zone," as there is no fossil, that I know of, peculiar to it.

The succeeding and last portion of the Flint-bearing Chalk is of far greater interest, both by the nature of its flints and by the number of remarkable fossils it contains. Described generally, it may be said to consist of a moderately hard chalk, with irregular bands of flint, which are sometimes of considerable thickness, but always more or less dogger-like and not continuous for far, or with thinner bands, which are likewise discontinuous. This phenomenon is exceedingly well described by Young and Bird as visible at Flamborough, where they argue that the flint cannot be said to be interstratified, but only interbedded, as you cannot follow either the thick masses or the thin sheets for any distance. This peculiarity, as far as I have seen, however, belongs only to the upper portion of the chalk rocks, which are those here exposed, and it characterises the same portion throughout the county. Perhaps we may say that the lower part of this upper series has thicker flints and the higher part thinner ones, but both are equally variable. This is particularly well seen near Fimber, and has doubtless influenced both the Messrs. Mortimer in their theory of the formation of flint. But a more remarkable phenomenon is to be seen in the interior of the larger masses of flint. Their exterior is generally, but not always, well marked, but on breaking them open, they are found to be by no means entirely composed of flint, but are rather an aggregate of angular masses of siliceous matter, shading off rather rapidly into calcareous, and enveloped in a siliceous envelope, just as if a number of neighbouring flint fragments had been cemented by a calcareous paste, and the outer ones had coalesced, and bound them together in one mass. It seems to me that we have here an illustration of flint imperfectly formed, or, in other words, in progress of formation. That the actual beds now exposed at the surface have their flints in any sense "growing," I do not believe; but I have little doubt that these beds were uplifted before the process was complete, and that in parts of the same stratum, buried beneath superincumbent strata, and in a suitable situation, the work may still be going on, just as in other

cases, from the rocks being left in other circumstances, it may not yet have begun. That these immature flints are confined to a geological horizon, and are not a geographical peculiarity, as they would be if always found to the west, with the Flintless Chalk to the east, is proved in the neighbourhood of Fimber—where the latter overlies the other vertically, capping the hill-top, whose *eastern* slope contains these flinty bands.

In addition to the sections on the coast, where they do not seem to be very fossiliferous, these beds may be well seen in the quarries near Hunmanby, especially in the "Butts Quarry." The chalk is much softer here than in the lower beds, but the flint is abundant, and we come upon a new fauna. Brachiopoda seem to have renounced their prominent position, and to have given way to echinoderms; none of the former could I find, but *Ananchytes ovatus* in some of its many varieties, so common in the Upper Chalk generally, and which Dr. Barrois records as *Echinocorys gibbus*, is abundant; and *Micraster coranguinum* also occurs. Some of these are overgrown with parasites such as *Spondylus latus* and polyzoa, which the beautiful drawings of D'Orbigny enable us to recognise as possibly his *Cellepora zenobia* and *Alecto longiscata* The common *Inoceramus Cuvieri* is also exchanged for *I. Brongniarti.*

I have seen what seems to be the same portion of the series, exposed in the quarry near Weaverthorpe vicarage, where the beds are vertical; from this place have come *Terebratula carnea*, and a fine large specimen of *Inoceramus Brongniarti.* A few hundred yards to the east of this pit we come to the soft, flintless chalk, lying horizontally. Continuing the circle, we find that the localities which have yielded Mr. Mortimer's fossils from what he calls the Upper Chalk with flints, all lie upon it. These are Lutton, Towthorpe, Fimber and Fridaythorpe. I have not seen much of it in this range, but just beyond, on Huggate Wold, it is very well exposed, both in the nature of its flints and in its fossils. All about here is the home of the wonderful *Inoceramus involutus*, of which Mr. Mortimer has several perfect in both valves. I found this in more than one quarry, so that it cannot be scarce, and being perfectly recognisable, would be very useful to characterize the zone, were it not that *Micraster corangiunum* has the priority. Associated

with it are *Terebratula carnea*, *Spondylus latus*, *Ananchytes ovatus*, *Ventriculites simplex*, *Brachiolites*, sp., and *Scyphia pedunculata*, of Römer, a remarkable hexactinellid sponge, now calcareous, and consisting of an external and an internal layer. I have not traced this series further south than the Millington coomb before mentioned, but have no doubt of its continuance in character through the whole district, since the highest beds visible, three miles west of Cottingham, have exactly the same character as to their flints, in their discontinuousness and imperfect formation, and though less fossiliferous contain *Ananchytes ovatus*, fish vertebræ, and what might possibly be *Inoceramus involutus*. When Mr. Mortimer's collection comes to be thoroughly examined it will be found, I think, that his most remarkable additions belong to this zone. What I have seen of that collection enables me to add the following :—There is first a large ammonite, probably *A. Lewesiensis*, measuring 3 ft. 4 in. in diameter, and found, I think, near Sledmere ; also what is equally or more rare in these beds, a *Pleurotomaria*, not unlike *P. perspectiva ;* on a specimen of *Micraster coranguinum*, from near Wharram, is a radiated *Anomia ;* also *Spondylus truncatus*, from Lutton, and the free valve of *Spondylus latus*, from Towthorpe, imbedded in a flint. There is the huge *Inoceramus digitatus*, its long fingers spreading over an area of 20 in. by 10 in., and a fine specimen of an *Inoceramus* of a new species, of transverse shape, and in aspect like a *Hippopodium*. The Mollusca are concluded with *Rhynchonella Mantelliana*, with the addition of a remarkable polyzoon, with a hair-like fringe on either side, imbedded in flint, described by Lonsdale in Dixon's "Fossils of Sussex," as *Syphoniotyphlus plumatus*. Among the echinoderms there is a species of *Cyphosoma* in a cast only ; some plates of a *Cidaris*, which is very like *C. subvesiculosa* but it has crenulated bosses ; also *Micraster cortestudinarium*, from Burdale, and what may be *Holaster trecensis*, from Sledmere. There is also a very peculiar form of almost beaked *Cardiaster*, called *C. excentricus*, by Forbes.* If to these we add *Parasmilia centralis*, in flint from Towthorpe, and a *Brachiolites* or *Cœloptychium*, also in flint, we shall exhaust all that I can name.

With regard to the highest zone, or Flintless Chalk, it is so well known, and its fossils have so long been studied, that I have but

* From the Upper Chalk of Norfolk.

little to say. I have seen numerous pits in it near Beverley, and between Driffield and Burton Agnes, along the eastern edge of the Wolds—and I cannot say that it seems any more fossiliferous than the rest of the chalk of the inland districts. A friend of mine at Beverley, Mr. Gilby, has long been seeking to collect fossils from the quarrymen there, but with little success ; nor did I find many. They do, of course, occur, but only scarcely, as in the beds below. The fossiliferous cliff at Dane's Dyke, is therefore quite an exception, and fortunately at a spot attractive for other reasons. The line of junction between this series and the zones of flinty chalk would not be very easy, therefore, to draw, as they are both soft near the junction. It has been attempted, however, by Mr. Mortimer, of Driffield. The quarry in this chalk near to Speeton Station, mentioned by Dr. Barrois, and which I have verified, is a caution against drawing a uniform line, as this is far to the north-west of its natural position, and is probably an outlier. Similar outliers cap the hills between Fimber and Fridaythorpe, and Life Hill, near Sledmere, according to Mr. Mortimer, and are said to have an effect on the agricultural properties of the soil.

No better name than the Zone of Marsupites could possibly be invented for this, as they are so common at Dane's Dyke, and a smoother species (*M. lævigatus*) occurs at Fimber. I quite agree, also, with Dr. Barrois in his observation that it is divisible into two parts, the lower part with many Marsupites and few Sponges, and the upper part with the relative frequency of these fossils reversed. Dr. Barrois asserts that the zone of *Belemnitella mucronata* does not occur in Yorkshire. Though I am not prepared at present to indicate a new fauna related to the upper part of the beds that would be worthy of a zonal distinction, yet I think it probable that the *B. mucronata* occurs, as was recorded long ago by Prof. Phillips. Of course, *B. quadrata* is there in abundance, but there are specimens which are stouter, rounder, and mucronate. I have not, however, been able to examine their alveoli. If this zone occurs anywhere it will be by Driffield, whence these specimens come.

Of fish there is *Ptychodus latissimus*, represented by a magnificent tooth from near Fimber. The Cephalopoda are *Nautilus lævigatus*, *Hamites cylindricus*, and *Scaphites binodosus*, *S. inflatus*,

and *S. compressus*, all figured by Römer from the Upper Chalk of Germany, and really belonging in part to the zone of *Belemnitella mucronata*. The only other mollusc is a beautifully-brown-coloured specimen of *Avicula tenuicostata* of Römer, from near Sledmere. From Driffield the most remarkable fossil is *Ananchytes pillula*, and a *Cœloptychium*.

There remains to complete this imperfect sketch a few observations to make on the probable thicknesses of the Chalk.

It would certainly appear from the uneven nature of the surface on which it rests, that the Chalk cannot be of uniform thickness throughout, nor should we suppose it to be so from the circumstances of its deposition. In many cases, however, it is most likely to vary in thickness by the absence of some of the lower beds than of its generally slighter development, and to estimate the importance of the series we must look to those localities where each part is best developed.

We have seen that at Speeton we must reckon at least 100ft. for the united zones of *Belemnites minimus* and *Holaster subglobosus*, though estimated at 70ft. only by Dr. Barrois. Other places where we may estimate the united thickness of these zones are first:—at Ganton, at which place the base of the Red Chalk is 200ft. above Ordnance datum, and at 300ft. we are inthe nodular-flinty chalk above, which leaves a maximum of 100ft.; so to the south of Sherburn we have Red Chalk at 200ft., flinty chalk at 300ft., and, more satisfactorily south of West Heslerton, we have the topmost band of coloured chalk about 300ft., and the Red Chalk proper certainly some distance above 200ft., the series in this direction both rising and thinning. As these are the zones most affected by the form of the underlying surface and conditions of deposit, we shall not expect to find so great a thickness on the western escarpment. At Wharram we have indications of about 50 feet of the Grey Chalk, but at Greets Hill, near Acklam, we have a maximum limit of 40 feet, and it may be much less. On the other hand, near Market Weighton, we have a minimum of 30 feet for the Grey Chalk alone, and at about 20 more feet below it is the true Red Chalk, making at least 50 feet. Near Welton, again, at a level of 150 feet, we have the base of the Red Chalk indicated by the copious springs, and at 275 feet,

quite close at hand, a quarry in the Flinty Chalk, this latter, however, is probably some way up in the overlying beds, and I should not be inclined to allow more than 75 feet there for the total thickness of the lower beds.

The next two subdivisions included in the zone of *Inoceramus mytiloides* must also be of considerable thickness. At Speeton a cliff 250 feet in height contains nothing higher than these, leaving a balance of 150 feet as a minimum after subtracting the lower zones. At Ganton these same beds are continued to a height of 520 feet, leaving a balance for their thickness of at least 220 feet. Near the Settrington Whams, where these beds lie directly on the Kimmeridge Clay, at a level of about 400 feet on the average, the Settrington High Street quarry in the zone of thick-bedded flints lies above the 600 feet contour—suggesting, again, about 200 feet. At Burdale tunnel the massive flints occur also at 600 feet, while we are not in the Grey Chalk at 400 feet; but in one sense this can only be used as a maximum, as the beds are dipping in the direction of the lower level. By calculations of dips and positions in the southern extreme between Melton and Hessle it would appear to be 250 feet, but that includes some, at least, of the beds above, though none of the higher imperfect flint series, so that for the beds now being estimated we may strike an average of 200 feet.

The barren zone, with thick flints, is probably but a thin one. It is not worth while spending time on its estimation, for which perhaps a maximum of 50 feet may be allowed.

To estimate the thickness of the zone of Micrasters, or Chalk with imperfect flints, there are not many satisfactory opportunities. It might be seen at Flamborough by taking a boat; but I have not done so. Near Fimber the Chalk without flints stands at a level of 470 feet, and the thick-bedded flints near the railway at 350 feet, leaving a balance of about 120 feet. But the amount will be, perhaps, best checked by making an estimate of the total thickness of the Chalk from the basal Red Chalk to the limit of the flints, which should be, when all is complete, the sum of 100 feet, 200 feet, 50 feet, and 120 feet—that is 470 feet.

Nowhere along the northern outcrop can a satisfactory estimate be made, because the higher beds are too much denuded. But

towards the centre of the western face we have two opportunities. First we have the Red Chalk occurring at a level of about 475 feet going up Garrowby Hill. This hill reaches a level of 810 feet without entering the flintless chalk, and there is a dip in the direction of the higher level. If the amount of dip between Fimber and Fridaythorpe were continued as far west as Garrowby (and one would expect it rather to increase than diminish) the base of the flintless Chalk would stand at 1,000 feet elevation, leaving 525 feet for the lower portion. Secondly we have the coomb leading down from Huggate to Millington. At Millington Springs the Red Chalk stands at 300 feet; the difference of elevation between this and Garrowby being due to its more eastward position, which also brings it on the same line of strike with the hill which gradually slopes up from this spot to a level of 820 feet, giving again an estimate of 500 feet. In the district south of Market Weighton, where the Red Chalk stands at a level of 220 feet, a height of 535 feet is reached at Hunsley Beacon, which, allowing for the dip proved in the neighbourhood, would give a total thickness of 440 feet for part only of the series.

The thickness of the Flintless Chalk can have no maximum assigned, because we know nothing of the overlying beds which must have been more or less denuded, but a minimum can be accurately obtained by measurement along the coast between Sewerby and Flamborough Head. I have measured these beds carefully, perpendicular to their stratification, and find 192 feet rising in succession up to Dane's Dyke, the marsupites becoming common at about 120 feet below the top. At Dane's Dyke there is a gap, and the continuation of the beds has to be approximated to; beyond this I measured 130 feet more without flints as far as it was safe to go, but I did not reach the base. We may then, I think, put the Flintless Chalk at 320 feet. Dr. Barrois' estimate is 260 feet, which is not very much less. Adding this to 470 feet, and more belonging to the red, grey, and flint bearing Chalk, we have a total in round numbers of 800 feet, which, as we have seen, is by no means an extravagant estimate.

The results arrived at may be therefore summed up in the following table, which represents the subdivisions and characters both lithologically and palæontologically :—

TABLE OF THE SUBDIVISIONS OF THE CHALK OF YORKSHIRE.

No.	LITHOLOGY.	PALÆONTOLOGY.		THICKNESS IN FEET.
1	Soft Chalk without flints	Belemn. mucronata / many sponges ... / few sponges	Zone of Marsupites	320
2	Chalk with imperfect flints	Zone of Micrasters		120
3	Chalk with many tabular flints	Barren zone		50
4	Slaty Chalk with thin flints .... / Creamy Chalk with nodular flints	Zone of Inoceramus mytiloides		200
5	Grey Chalk without flints	Zone of Holaster subglobosus		100
6	Red Chalk	Zone of Belemnites minimus		

It will be seen on a comparison of this table with that of Dr. Barrois before given, that I suggest the use in the present stage of our knowledge of larger subdivisions than he admits. It may be true, perhaps, that the smaller ones may be adequately recognised when more work has been done upon the district, and the map of it carefully worked out by stratigraphical observations, but the first step seems to be to mark out the more easily recognised portions before proceeding to the more minute. Indeed, the French who set the example in drawing up these divisions and subdivisions, recognise larger groups, which they call "assises," and it is really these and not their zones which correspond with my subdivisions. Indeed, were it not for what I call the Barren zone, which is separated merely for lithological reasons, and which might otherwise be well included in the zone above, the two sets would compare exactly. Those subdivisions of Dr. Barrois that I do not recognise are—1st, the zone of *Micraster cortestudinarium*, of which urchin I have only seen one example in Mr. Mortimer's collection, and do not know its exact bed in relation to the others; 2ndly, the zone of *Holaster planus*, authentic specimens of which I have not met with, and 3rdly, that of *Terebratulina gracilis*. Three zones may also ultimately be recognised in what I have characterised as one, but

in that case the *Inoceramus mytiloides* will be found to characterise the middle one rather than the lowest.

It would open up too large a subject to discuss generally the relations of the Yorkshire Chalk thus divided with that of other districts, but so interesting are they in their real similarity of development that I cannot refrain from making one or two observations on the subject.

The lower portion, with the exception of the thin local bed of *Belemnites plenus*, which probably did not extend into Yorkshire, and other limited developments at the base, corresponds admirably with the series so well described lately by Mr. Price* as occurring at Folkestone. In Yorkshire the nodular flints begin a little sooner, where, in Kent, it is nodular chalk. As to the higher portion, the Chalk of Margate, which represents the zone of Marsupites, is so far less flinty than the Micraster zone, that it may almost be called flintless, though it is not absolutely so, as in Yorkshire. Again, with regard to Sussex, the structure of the Chalk of the zone of *Holaster subglobosus* is singularly like that which is presented by the Grey Chalk of Yorkshire.

The Chalk of Sussex belonging to the zone of *Inoceramus mytiloides* is not without flints in its upper parts certainly, and the flints which do occur in it are nodular and sparse, and are placed in the same manner as in the North; while the hardest chalk, known as Chalk-rock in the South and the Creamy Chalk in Yorkshire, is developed in both areas on about the same horizon. The Chalk with flints includes the zone of Micrasters, which also contains flints in the North, and certainly at Brighton the flints become less numerous as the Marsupite zone is approached.†

Regarding larger subdivisions, the three upper series of the Yorkshire Chalk, if lithologically distinct, are closely connected together palæontologically by the abundance of their Echinoderms, and would, together, represent the "Upper Chalk" of the South—the "Senonien" of the French. The zone of *Inoceramus mytiloides* by itself represents the "Lower Chalk" or "Turo-

* Quart. Journ. Geol. Soc., Vol., xxiii., p. 431.

† Since this paper was read, Professor Judd has given us his admirable description of the Cretaceous rocks of Scotland, and one cannot help noticing that the part of the Chalk which is there represented by carbonaceous beds has thin streaks of similar material in it in Yorkshire as noticed at Welton and Londesborough.

nien," and the "Grey Chalk," or zone of *Holaster subglobosus*, is the Chalk Marl or "Cenomanien."

The Yorkshire Chalk, then, is not so anomalous as to its flints as was at first supposed, and shows essentially the same succession of life as is found elsewhere. It would thus appear that on lithological grounds we might divide the Chalk throughout England into three portions. 1st, a Lower Chalk—absolutely flintless below, and very sparingly flinty towards the top—the amount of the flint introduced varying in different localities; 2nd, a Middle Chalk, everywhere characterised by abundance of tabular flints, or flint nodules in regular lines; and, 3rd, an Upper Chalk, almost and sometimes quite flintless towards the base, and becoming absolutely so towards the top. These different portions have different developments in the various localities, so as to have caused either the Upper or Lower Chalk to have been almost overlooked; and if this arrangement be adopted, it is neither of these subdivisions but the Middle Chalk that ought to be called the "Chalk with flints."

Although the fossils, which from their wide geographical but limited geological range have been happily chosen to represent the succession of life, are found in the North in the same order of time as in the South, there are others more local, by which the southern chalk has long been known, which are still absent from Yorkshire, and seem to indicate a deposition in a somewhat separated area. Thus, throughout the whole series we notice the remarkable absence of gastropods of any kind, the *Pleurotomaria* from Fimber being the only one known. Nor do we find any of those teeth of carnivorous sharks which are elsewhere so numerous—the only shark's teeth belonging to allies of the recent cestracion, which is a harmless feeder on vegetables and small animals. The ammonites and other cephalopods, too, which might have been carnivorous, are very sparsely represented; so that on the whole the animals of the lamellibranch, brachiopod, and echinoderm Classes which could subsist in these seas must have had a pleasant time of it. Regarding the Cephalopoda generally, it is also remarkable that no *Turrilites* or *Scaphites* are known in the lower beds, where they are so plentiful and characteristic in the South,* though the latter, with their allies, the *Hamites*, are found

* This may be accounted for, however, as suggested to me by Mr. Meyer, by the absence of the particular zone which should contain them.

in the upper beds—where they had almost died out in Southern England. Other notable absences, which may, however, be disproved by degrees, are those of the Crustacea, bony fishes, and Reptiles. In these respects, as well as in the identity of various particular species, we shall find, as has been pointed out many years ago, a far closer agreement, especially in the upper part, with the Chalk of North-West Germany, whose fossils have been described by Römer and others, than with that of our own southern counties.

There remain now but one or two points to be noticed regarding the physical structure of the Chalk. Some portions of it are very remarkable for the extreme development of the appearance known as slickensides. In some quarries every fragment has its surface covered with parallel lines at different levels, like a broken mass of basalt in miniature, or even like the appearance of a worn massive coral in which sometimes the outer wall or theca, sometimes the vertical divisions or septa are exposed, and the Chalk seems to be of this structure throughout. This peculiarity has been noticed before by Mr. Mortimer, who thought it was actually due to coral growth; that it is not is of course proved by the total absence of any real animal structure, the whole thing being due to an arrangement of the particles of the Chalk. The causes are, doubtless, as Mantell long ago said, the pressures and consequent motions of the Chalk while it was in a softer state. That when this structure was induced it had no cohesion, is proved by this slickenside appearance entering the hollow side of an *Inoceramus* without breaking the shell. The slickensided Chalk may be found all over the Yorkshire area, but it is nowhere so remarkable as near the change of direction of the line of outcrop—that is, a little north of its highest elevation. It is, therefore, very probably connected either with the deposition of the Chalk on a slanting surface, or with its subsequent unequal elevation. Whether pseudo-crystallization may be considered as taking part in this phenomenon I have no evidence to prove. This and the formation of flint are changes which took place in the Chalk before its elevation. It has always been noticed that the Chalk of Yorkshire is much harder than that in more southern counties; indeed, such chalk as that of Brighton, out of which one may extract fossils with a knife, is not known in the North. Whether

this is due to the chemical nature of its constituents, to the chemical circumstances it has been placed in, or to the lateral pressure it has been subject to, it is pretty certain it is not due to the vastness of the superincumbent pressure of any newer beds deposited on its surface. We have no evidence of such having ever existed.

An examination also of the minute structure of the Chalk throws but very little light on its hardness. This structure, however, is very interesting in itself. On washing down with a hard brush some of the softest chalk, *viz.*, that from Driffield, to find any microzoa it might contain, I was astonished to find that almost the whole of the material left for examination consisted of very minute hollow spheres. They are at present calcareous in structure, but I have not been able definitely to find any apertures in them; otherwise they look like the *Orbulina universa*, abounding to the extrusion of all other foraminifera. I can see no spines standing out from their surface which should approximate them to *Xanthidia* or the spores of sponges. In the specimen of chalk alluded to they are calcareous, but in another piece, now silicified, containing a fragment of *Ventriculites*, they are also silicified, so that their present state is no clue to their original substance. A somewhat analogous phenomenon occurs in the Corallian beds, where the little kidney-shaped organisms, which I thought I had proved to be foraminifera and called *Renulina Sorbyana*, occur as abundantly in a calcareous state in the Rag of Wiltshire, and still more abundantly in a siliceous state in the Calcareous Grit of Scarborough. If we could make out their true nature, it might throw light on the origin and formation of flint. It is very certain that animal silex in sponges breaks down in fossilisation, and may be replaced either by mineral silex or carbonate of lime, just as the converse phenomenon of the breaking down of animal carbonate of lime and its replacement by mineral silex or carbonate of lime is known to occur. It may be then that these little globes were originally siliceous, and that their siliceous matter is distributed through the mass, or possibly carried away to lower beds. If, on the contrary, they were originally calcareous, they have been silicified in some instances. The general nature of the origin of the flint, though connected with this, can scarcely be here touched upon. It is to be noted, however, that in the Flintless

Chalk the sponges are mostly siliceous, but occasionally calcified. In the Flinty Chalk they are mostly calcified, but occasionally siliceous. In the latter case they retain their beautiful hexactinellid structure in their original substance. We have also to account for beds of flint of some thickness and the varying forms in which it occurs. That it is in any way specially connected with sponges, I do not for a moment believe, unless the little spheres above mentioned turn out to be their spores or spicules, which to my mind seems far from probable; but that the silex is derived from animal structures imbedded in the Chalk, and that its extraction depends upon the circumstances in which the stratum is subsequently placed, seems pretty evident.

Since its upheaval the Chalk has been subject to a considerable scraping, and to the action of some force, which has been strong enough to take hold of huge masses and contort them and stand them on end. A remarkable folding in the rocks was noticed many years ago at Scale Nab on the coast by Professor Sedgwick—an equally noteworthy instance of similar action has come under my observation on the summit of the crest between Sherburn and Weaverthorpe. On ascending the hill from Sherburn is a large quarry with the chalk perfectly horizontal, and not more than 20 feet above the level of its upper surface are found beds belonging to the next higher portion of the series standing up nearly vertical, having a dip of 70° to the south. The interstratified bands of flint and the cross veins of calcite—more numerous here than elsewhere, possibly owing to the easier infiltration of water through beds in such a position—give the small quarry face a very marked appearance. The same beds are seen crossing the surface of the road to a length of nearly 70 feet, so that we must have as much as 60 feet thus set on end. This is partly seen in the following view.

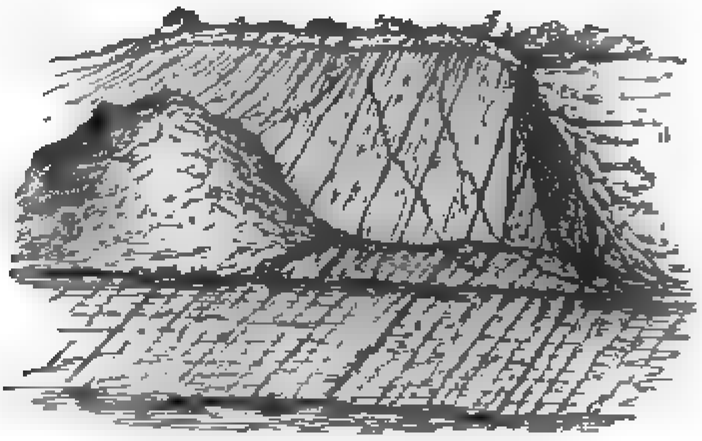


FIG. 4.—QUARRY BETWEEN SHERBURN AND WEAVERTHORPE.

If we continue upwards a little higher we find a still more marked disturbance about the 500 feet level. Not only are the beds tilted up, but they are actually inverted, so that instead of dipping south at a very low angle they are dipping north at about 45°, having been turned through an angle of 135°. The date of this disturbance is also indicated by these Chalk beds (perhaps as much as 12 feet of them seen) actually lying upon stratified quaternary sand, which forms the mound on which they were stopped. These phenomena indicate a powerful force coming from the direction of the north during a season in which the lower levels were protected from its influence. Geologists will see in this, doubtless, another form of those glacial forces which have strewed the bottoms of the valleys, and in some instances hollows at high elevations with boulders and clay.

In the quarry near the vicarage at Weaverthorpe, as before mentioned, rather a similar phenomenon occurs, though probably due to a different cause. In this instance, we have on all sides of the quarry, at comparatively short distances, horizontal beds on the same geographical level, and yet the chalk in it stands nearly vertical, and dips actually northwards into the hill, which, as a whole, is massive and not disturbed. It is difficult to conceive any external force which should act in so local a manner on the side of a valley without affecting the hill above it. Of course this quarry happens to be opened in a huge mass which has broken off the rest, and has fallen, or been forced, over on to its end, and on going into the hill we should soon find the line of fracture. But what was it that broke off the mass and uptilted it? The most probable explanation that suggests itself to my mind is connected with the springs known as "the Gypsies." The stream, whose underground water pressure is relieved by these intermittent springs, takes its rise at Wharram, whence it continues as an ordinary rivulet till it reaches a spot very near to this quarry at Weaverthorpe. Here it partly sinks into the earth and disappears. This is the only stream that runs across the Wolds, taking its rise on the west and running eastward; and it seems to me to be connected with the underground configuration of the strata. We have seen what a high level the Kimmeridge Clay maintains in Burdale Tunnel, and it is the same on the other side of Wharram. This keeps up the water that falls through the higher crevices of the Chalk, and sends it out

again through the lower ones. The same thing happens near Weaverthorpe, where the Kimmeridge or Neocomian clay is probably at no great depth, though a well was sunk at that village through 100 feet without reaching it, and the water there finds a subterranean passage ; it eats away the subjacent clay ; the chalk here and there has its support taken away, it breaks off, and the end of the mass nearest the hill, sinking down more rapidly from its greater weight rotates the whole till it takes up the position in which we now see it.

The phenomena of surface denudation are well manifested by some parts of the Wolds, as, for example, between Wetwang and Huggate, where the flints have been left behind in great numbers, the Chalk having been dissolved away ; and a fact related to me by Mr. Mortimer, of Fimber, seems to give us a clue to the rate at which the denudation is now going on. He has observed in his examination of the tumuli that the natural surface of the chalk rock beneath them is always about a foot higher than that of the surrounding field. This foot of chalk then has been denuded off the exposed parts, and not off the protected during the interval since the tumuli were made. I do not know what date the archæologists assign to these, but this might be the means of estimating how long the denudation of one foot has required.

There are other points of interest connected with the Chalk of Yorkshire which might be enlarged upon, but I have said enough at the present time, and I can only hope that this brief outline of the facts connected with the formation and its relation to those of other areas will encourage examination of a district which, after all, is neither uninteresting nor barren.

LIST OF FOSSILS MENTIONED IN THIS PAPER.

Ptychodus mammillaris, 4.*
latissimus, 1.
Nautilus Bouchardianus, 6, 5.
lævigatus, 1.
Ammonites peramplus, 6, 5.
Lewesiensis, 2.
Scaphites binodosus, 1.
inflatus, 1.
compressus, 1.
Hamites cylindricus, 1.
Belemnites minimus, 6.
Belemnitella quadrata, 1.

* The figures indicate the subdivisions in which the fossil is found ; those species which are written in italics are recorded for the first time.

Pleurotomaria perspectiva, 2.
Plicatula *pectinoides*, 6.
Avicula gryphæoides, 6, 5.
tenuicostata, 1.
Spondylus *fimbriatus*, 4.
latus, 2.
Kingena lima, 6, 5.
Actinopora calyx, 5.
Cellepora Zenobia (?) 2.
Alecto longiscata (?) 2.
Siphoniotyphlus plumatus, 2.
Cidaris cf *subvesiculosa*, 2.
gaultina, 6.
Cyphosoma sp., 2.
Pseudodiadema *ornatum*, 5.
Salenia granulosa, 4.
Holaster subglobosus, 5.
suborbicularis, 6.
cf *integer*, 5.
(?) trecensis, 2.
Inoceramus sulcatus, 6.
tenuis, 6.
Cuvieri, 4, 3.
mytiloides, 4.
Brongniarti, 3, 2.
involutus, 2.
digitatus, 2.
lingua (?) 2.
nov. sp., 2.

Anomia, 2.
Terebratula biplicata, 6.
semiglobosa, 6, 5, 4.
capillata, 6.
sulcifera (?) 6. (?)
carnea, 2.
Terebratulina gracilis, 4.
Rhynchonella Cuvieri, 4.
Mantelliana, 2.
Wiestii, 6.
lineolata, 5.
latissima, 6.
Cardiaster excentricus, 2.
rostratus, 5, 2.
Discoidea cylindrica, 5
Echinoconus subrotundus, 4.
Ananchytes ovatus, 3, 2.
pillula, 1.
Micraster coranguinum, 2.
cortestudinarium, 2.
Marsupites ornatus, 1.
lævigatus, 1.
Bourguetecrinus rugosus, 6.
smooth sp., 6.
Parasmilia centralis, 2.
Brachiolites, 2, 1.
Ventriculites simplex, 4, 2.
Scyphia pedunculata, 2.

ORDINARY MEETING, January 4th, 1878.

Prof. John Morris, F.G.S., President, in the Chair.

The following Donations were announced:—

"Report of the United States Geological Survey of the Territories," Vol. xi., by F. V. Hayden.

"Ninth Annual Report of the United States Geological and Geographical Survey of the Territories, &c., 1875," by F. V. Hayden.

"Bulletin of the United States Geological and Geographical Survey of the Territories," Vol. iii., No. 4.

"Fur-bearing Animals; A Monograph of North American Mustelidæ, &c.," by Elliott Cones.

(All four presented by F. V. Hayden.)

"Geology of Leicestershire and Rutland," by W. J. Harrison, F.G.S., from the Literary and Philosophical Society of Leicester.

"Céphalopodes—Étude Générales," by J. Barrande; from the Author.

"Abstracts of the Proceedings of the Geological Society of London," Nos. 342, 343; from that Society.

"Transactions of the Watford Natural History Society," Vol. i., Part 8; from that Society.

"Journal of the Quekett Microscopical Club," No. 35; from that Club.

"The Worth of Life," an Address delivered at the Opening Meeting of the 58th Session of the Leeds Philosophical and Literary Society, by William, Lord Archbishop of York; from that Society.

"Journal of the Society of Arts," Dec. 14, 21, 28 (1877), and Jan. 4 (1878).

"A Treatise on Diamonds and Pearls, &c.," by David Jeffries, 4th edit.; from Prof. J. Tennant, F.G.S.

"Annual Report of the Board of Regents of the Smithsonian Institution, &c., 1876;" from that Institution.

The following Paper was read:—

On the Insect Fauna of the Secondary or Mesozoic Period, and the British and Foreign Strata in which Insect Remains have been Detected.

By Herbert Goss, Esq., F.L.S., F.G.S., F.Z.S.

ANNUAL GENERAL MEETING, February 1st, 1878.

Prof. John Morris, F.G.S., President in the Chair.

The Honorary Secretary read the following :—

Report of the General Committee for the Year 1877.

The Report of your Committee for the past year shows the continued steady progress of the Association.

Members elected during 1877 . . .		49
Deaths	7	
Withdrawals and exclusions	15—	. 22
Increase		27

The Census of the Association for January 1st, 1878, was as follows :—

Honorary Members	11
Life Members	58
Old Country Members . . .	21
	90
Other Members	315
	405

Showing a total of 405 Members.

Having passed another hundred, a brief retrospect might be of interest. In 1870 there were 219 Members, of whom 54 were old country Members, paying an annual subscription of 5s. only. In 1877 there are 405 Members, of whom only 23 are old country Members, showing an actual increase of 186 Members in seven years, or say 27 each year. If 27 more Members are added to the number during the current year, the Association will nearly have doubled itself in eight years. These figures speak for themselves, and are more significant of the interest taken in the Association, and of the want it has supplied, and no doubt also stimulated, than anything your Committee could add.

Whilst congratulating ourselves on the progress we are making, and the steady increase to our numbers, we have from time to time to lament the death of some who, from the work they have done, cannot be passed over without special notice. During the past year seven of our Members have died, viz., Mr. W. R. Brodie, Mr. F. Clarkson, Mr. J. Leckenby, Mr. C. W. Rothery, Mr. E. F. Teschmacher, Mr. C. Woodward and Mr. M. Greene. Mr. Clarkson was an assiduous member of your Committee. Mr. Leckenby, of Scarborough, added largely to our knowledge of the Mesozoic Strata of East Yorkshire, and his fine collection of fossils, the result of many years labour, is now in the Woodwardian Museum at Cambridge. Mr. Rothery was also a diligent worker, and made a large and interesting collection.

The Finances of the Association are in a very flourishing condition. There is a balance for the year of £113; of this the Committee recommend that £57 15s.—the amount of the Life Compositions of Members during the year—be invested in Consols, which, with the sum already so invested, will make about £338. Altogether, on the 31st of December, the Association had a capital of nearly £400, after all expenses were paid up to that date.

The amount obtained from Entrance Fees and Annual Subscriptions during 1877, was 23s. less than in 1876; whilst that from Life Compositions was £36 15s. more. This great increase in the number of Life Compositions has its drawbacks as well as its advantages, for whilst it shows great confidence in the solid and enduring basis on which the Association is built, the interest accruing from the capitalised amount is hardly an adequate set-off for the loss of so many Annual Subscriptions, and it might become a question whether it were not advisable to raise this fee.

The four numbers of the Proceedings of the Association, containing 190 pages, published during 1877, have given to Members several papers of importance, and interesting reports of the Field-work for which the Geologists' Association is so justly famed. Your Committee had great pleasure in publishing the two Presidential Addresses by William Carruthers, Esq., F.R.S., with which

Volume V. commences, since they are so full of the results of their observations and research of our most eminent fossil botanist. The thanks of the Association are due to Professor Owen for the great pains he took to render the reports of his two lectures at the British Museum as complete and as accurate as possible. These articles, treating as they do of subjects of which the learned Professor is alone the master, give great additional value to the Proceedings.

Extensive use still continues to be made of the Library, and is satisfactory to notice that the standard works and text-books on Geology seem as hitherto to be in especial request; and it is hoped that, during the coming year, Members will avail themselves to a yet greater extent of this valuable privilege, and with this view the new Catalogue, now in course of preparation, will be issued as soon as possible. Numerous additions, by donation and the exchange of Proceedings, have been made to the Library during the past year, and attention is again called to the valuable publications of the United States Geological and Geographical Survey of the Territories, for which the Association is indebted to the great liberality of the Director, Dr. F. V. Hayden, who undoubtedly deserves your special thanks for such important donations.

During the year 1877 the following Museums and Collections were inspected :—

British Museum—	
Fossil Marsupialia, from Australia	Prof. Owen, LL.D., F.R.S., &c.
British Museum—	
Fossil Reptilia from South Africa	Prof. Owen, LL.D., F.R.S., &c.
British Museum—	
Fossil Fishes	Wm. Davies, Esq F.G.S., and I Woodward, Es F.R.S., F.G.S.
Royal College of Surgeons—	
Red Crag Mammalian Remains...	Prof. Flower, F.I F.G.S., &c.
Wantage—	
Collection of Sponge-Gravel Fossils, &c. ...	E. C. Davey, E F.G.S.

—

History Museum...	Rooke Pennington, Esq., F.G.S.
•	
latural History Museum—	
llection of Crag Fossils	Dr. Taylor, F.G.S., F.L.S.
—	
l History Museum...	W. J. Harrison, Esq., F.G.S.
ı—	
ion of Chalk Fossils of the District ...	J. Cluse, Esq.
ıd—	
ion of Tertiary Fossils	Caleb Evans, Esq., F.G.S.

ommittee would desire specially to call the attention of to the very instructive and interesting expositions given tish Museum and the Royal College of Surgeons. To Owen the thanks of the Association are especially due ıd manner in which he invited the Members to the British where he explained to them, on two different occasions, ections of fossil remains from South Africa and Australia, h this modern Deucalion has peopled those continents ptilian and Marsupian fauna far more wonderful than any- ıythological story.

or Flower's exposition of the Crag fossils in the Museum llege of Surgeons, coming, as it did, just after the Ipswich , added greatly to its value as a lesson in scientific palæon- ; distinguished from the mere heaping up and naming of ıe very extensive collection of fossils in the British Museum rse, well known, but it may not be so generally known that yal College of Surgeons there is a very large collection rate remains, as well as of the teeth, bones, &c., of exist- ɔrata, arranged and exhibited so methodically, and so fully in the Catalogues, as to afford the student of Geology ıt facilities for comparing his fossil specimens both with ɔecimens in the Museum and with their nearest living as Prof. Flower showed with regard to the fossils from

ccursions still continue one of the most attractive features ssociation, as is shown by the ever-increasing numbers of

those who take part in them; nor are these by any means confined to our own Members, for we are joined by many who are not, more especially if in the locality visited there happens to be some kindred society, as is frequently the case, when we are sure of a very hearty welcome as well as a large increase to our numbers, and frequently to our Members also.

The success of these Excursions is due principally to the very able men who are ever willing to be our Directors—for what locality could not be made geologically interesting by one who thoroughly understood it?—and, that we have been very fortunate in this respect during the past year, the subjoined list will show:—

Directors of Excursions during 1877. W. Whitaker, Esq., B.A., F.G.S., of the Geological Survey; Dr. J. E. Taylor, F.G.S.; E. Charlesworth, Esq., F.G.S.; Professor John Morris, F.G.S., on two occasions; E. C. Davey, Esq., F.G.S.; W. J. Harrison, Esq., F.G.S.; Rev. T. G. Bonney, M.A., F.G.S.; Rev. E. Hill, M.A., F.G.S.; J. Logan Lobley, Esq., F.G.S.; Caleb Evans, Esq., F.G.S.; R. A. C. Godwin-Austen, Esq., B.A., F.R.S., F.G.S.; Rev. J. Magens Mello, M.A., F.G.S.; Rooke Pennington, Esq., LL.B., F.G.S.

The Thanks of the Association are especially due to the following gentlemen, for assistance and hospitality at the Excursions:— E. C. Davey, Esq, F.G.S.; Sir Richard Wallace; the Proprietors of the Clay Cross Colliery; Rooke Pennington, Esq., LL.B., F.G.S.; Rev. T. T. Griffith, M.A.

Subjoined are the Formations visited during the Excursions, with their Periods, and the localities where they were examined:—

Period.	Formation.	Locality.	Date.
Recent.	Shingle Beach.	Landguard.	April 2.
Post Tertiary.	Cave Deposits.	Creswell, Poole's Hole, &c.	July 25.
„	Mammaliferous Deposits.	Grays, Essex, Chilworth.	April 21, June 23.
„	Boulder Clay.	Chillesford, East Norton, Mount Sorrell, Sudbourne, &c.	April 3, May 21, & 22, &c.
„	Chillesford Clay.	Chillesford and Sudbourne.	April 3.
„	Coralline Crag.	Sudbourne.	April 3.
Eocene.	London Clay.	Felixstow, Hampstead, &c.	April 2, June 16 &c.
„	Thanet Sands.	Grays, Essex.	April 21.
Cretaceous.	Upper Chalk.	Grays, Essex.	April 21.
„	Chalk Rock.	Wantage.	May 7.
„	Lower Chalk.	Wantage, Caterham	May 7, June 4.
„	Chalk Marl.	Guildford.	
„	Upper Greensand.	Wantage, Godstone.	May 7, June 4.

Period.	Formation.	Locality.	Date.
Cretaceous.	Gault.	Wantage, Godstone.	May 7, June 4.
"	Lower Greensand.	Tilberstowe, Godstone, Nutfield, Guildford.	June 4.
Jurassic.	Northampton Sands.	Neville Holt.	May 21.
"	Lincolnshire Limestone.	Neville Holt.	May 21.
"	Upper Lias.	East Norton, Market Harborough, Neville Holt.	May 21.
"	Middle Lias and Marlstone.	Robin-a-Tiptoes, Market Harborough, &c.	May 21.
Trias.	Keuper.	Groby, Mountsorrel, &c.	May 22.
Permian.	Lower Magnesian Limestone.	Whitwell and Markland Grip.	July 24.
Carboniferous.	Coal Measures.	Clay Cross.	July 23.
"	Millstone Grit.	Stannedge.	July 28.
"	Kinderscout Grit.	Kinderscout, Rowter Rocks, Ratcliffe Rocks, &c.	July 27 & 28.
"	Yoredale Rocks.	Allport, Edale, &c.	July 27.
"	Carboniferous Limestone.	Ashover, Chee Tor, Matlock, Castleton.	July 23, 25, 28.
Lower Palæozoic.	Slates, Grits and Conglomerates.	Charnwood.	May 22.
Igneous or Metamorphic and Mineral Veins.	Elaterite.	Windy Knoll.	July 26.
	Lead Veins.	Tideswell, Miltown, Millersdale.	July 23, 25.
	Toadstone.	Millersdale, Ashover, Tideswell.	July 22.
	Syenite.	Groby.	May 22.
	Volcanic Agglomerates.	Charnwood.	May 22.
	Granite.	Mountsorrel.	May 22.
	Basalt.	Mountsorrel.	May 22.

The monthly meetings have been well attended by the Members, and no better evidence is needed of their appreciation of the papers and discussions than the large number who come to hear them and take part in them. As might have been expected from his great experience and scientific knowledge, as well as from the personal esteem in which he is held, the Opening Address of the Session by the President, Professor Morris, in November last, was very largely attended, and listened to with much interest.

There were exhibited at the Annual Meeting last February, a great number of excellent microscopic preparations of objects of geological interest, which was greatly enhanced by the explanations which were given of them. Among them was a beautiful collection, showing the structure and fructification of the vascular cryptogams of the Coal Measures, exhibited and explained by Mr. Carruthers; also specimens of Carboniferous Polyzoa and Sponge Spicules from Ayrshire, exhibited by Dr. Millar.

It is hoped that the great success which attended this Annual Meeting will lead to others of a similar nature.

The following is a list of the Papers, &c., brought before the Association during 1877 :—

On the Lower Bagshot Beds of the Hampshire Basin, by JOHN STARKIE GARDNER, Esq., F.G.S.
History of the Restorations of Extinct Animals, by the Rev. J. F. BLAKE, M.A., F.G.S.
On Certain Genera of Living Fishes and their Fossil Affinities, by Miss A. CRANE.
On Ironstone Nodules from the Shale Roofs of South Wales Coal Mines, by Colonel J. D. SHAKESPEAR, F.G.S., Assoc. Inst., C.E.
On the Geology of Leicestershire, by W. J. HARRISON, Esq., F.G.S.
On the Forms of the Genus Micraster common in the Chalk of West Kent and East Surrey, by CALEB EVANS, Esq., F.G.S.
On the Insect Fauna of the Tertiary Period, and the British and Foreign Strata in which Insect Remains have been detected, by HERBERT GOSS, Esq., F.L.S., F.G.S., F.Z.S.
On the Geology of that part of the Great Western Railway which extends from Banbury to Chipping Norton, by THOMAS BEESLEY, Esq., F.C.S.
Opening Address, Session 1877-8, by Professor MORRIS, F.G.S.
On the Chalk of Yorkshire, by Rev. J. F. BLAKE, M.A., F.G.S.

It is with regret that your Committee have received the resignation of Mr. Hopkinson, who for two years has so ably discharged the duties of Honorary Librarian, but finds that other engagements make it no longer possible for him to devote the necessary time to them.

Your Committee have recommended as his successor, Mr. B. B. Woodward, whose knowledge of the duties of a librarian, acquired in the most extensive field, will no doubt be turned to account for the benefit of the Association, more particularly in continuing the Catalogue so ably begun by his predecessor.

Your best thanks are still due to the Council of University College for the use of this spacious room for holding your meetings, and for assistance and courtesy at all times.

Your Committee have great pleasure and confidence in recommending for election as an Honorary Member of the Association, Professor Richard Owen, C.B., M.D., LL.D., F.R.S., F.G.S., &c., Chief of the Natural History Department of the British Museum.

Subjoined is the Balance Sheet for the year 1877 :—

For the Year ending December 31st, 1877.

Dr.

	£ s. d.	£ s. d.
By Balance, January 1st, 1877		71 1 6
,, Sale of Publications		4 1 6
,, January Dividend on £258 5s. 8d. (Consols) ...		3 16 6
,, July ,, £260 8s. 8d. ,, ...		4 3 1
,, Life Compositions		57 15 0
,, Entrance Fees	24 10 0	
,, Annual Subscriptions	138 8 0	
		163 18 0
		£303 15 7

Cr.

	£ s. d.
To Printing and illustrating "Proceedings"	76 3 6
,, Miscellaneous Printing, including the Report and List of Members	44 13 9
,, Library	3 10 6
,, Gas, Attendance, and Miscellaneous Items	19 9 5
,, Postages	28 18 11
,, Stationery	1 14 6
,, Consols	20 19 0
,, Broker's Commission	0 1 0
	190 4 7
Balance	113 11 0
	£303 15 7

We have this day examined the Accounts of the Geologists' Association, and we find that, according to the books laid before us, a sum of £113 11s. remained in the hands of the Treasurer on the 31st December, 1877.

J. BRADFORD,
R. W. CHEADLE, } *Auditors.*

JANUARY 25th, 1878.

The Report of the General Committee was unanimously adopted as the Annual Report for the year 1877.

The Ballot having been completed, the President announced that the following had been elected:—

GENERAL COMMITTEE AND OFFICERS.

PRESIDENT.

Professor John Morris, F.G.S., &c.

VICE-PRESIDENTS.

William Carruthers, Esq., F.R.S., F.L.S., F.G.S.
Henry Hicks, Esq., F.G.S., F.R.C.S.
Prof. T. Rupert Jones, F.R.S., F.G.S., &c.
Wilfred H. Hudleston, Esq., M.A., F.G.S., F.C.S.

TREASURER.

F. G. Hilton Price, Esq., F.G.S., F.R.G.S., M.A.I.

HONORARY SECRETARY.

John Foulerton, Esq., M.D., F.R.C.S.E., F.G.S.

HONORARY LIBRARIAN.

Bernard B. Woodward, Esq.

Rev. J. F. Blake, M.A., F.G.S.
Rev. Prof. T. G. Bonney, M.A., F.S.A., F.G.S.
Sir Antonio Brady, J.P., F.R.S.
Major Duncan, R.A., LL.D., F.G.S., &c.
H. G. Fordham, Esq., F.G.S.
George Berringer Hall, Esq., F.G.S.
John Hopkinson, Esq., F.L.S., F.G.S.
J. Logan Lobley, Esq., F.G.S., F.R.G.S.
Charles J. A. Meyer, Esq., F.G.S.
James Parker, Esq., F.G.S.
John Francis Walker, Esq., M.A., F.G.S., &c.
Henry Woodward, Esq., LL.D., F.R.S., F.G.S., &c.

The thanks of the Association were unanimously voted to Mr. John Hopkinson, E.L.S., for his services as Honorary Librarian during the past two years, and the proceedings of the Annual General Meeting then terminated.

ORDINARY MEETING, February 1st, 1878.

Professor John Morris, F.G.S., President, in the Chair.

The following Donations were announced :—

"Abstracts of the Proceedings of the Geological Society," Nos. 344-5 ; from that Society.

"Proceedings of the Bristol Naturalists' Society," Vol. ii., Part 1 ; from that Society.

"Proceedings of the Royal Society of Edinburgh," 1872-7 ; from that Society.

"Proceedings of the South Wales Institute of Engineers," Vol. x., No. 6 ; from that Society.

"Transactions of the Manchester Geological Society," Vol. xiv. Parts 15 and 16 ; from that Society.

"Journal of the Society of Arts," Nos. 1312-15 ; from that Society.

"Hydro-Geological Map of Urban and Rural Sanitary Authorities Districts of Alnwick," &c. ; from W. Topley, Esq., F.G.S.

"Geology of the Counties of England—West Riding of Yorkshire," by W. Harrison, F.G.S. ; from the Author.

"A Sketch of the Geology of Hampshire," by W. Harrison, F.G.S. ; from the Author.

The following were elected Members of the Association :— Thomas Calvert, Esq. ; Richard Hale, Esq. ; Miss Elizabeth Powell ; Lieut.-Col. J. C. Salkeld, F.R.G.S.

The following Paper was read :—

On the Lancashire Coal Field.

By C. E. De Rance, Esq., F.G.S., H.M. Geol. Surv.

The Insect Fauna of the Recent and Tertiary Periods, and the British and Foreign Formations of those Periods in which Insect Remains have been detected.

By Herbert Goss, Esq., F.L.S., F.G.S., F.Z.S., &c.

(Read June 1st, 1877.)

Introduction.

In the following paper I shall endeavour to call the attention of this Society to an interesting and important branch of Palæontology, which, until a comparatively recent date, had received but little notice, either in this country, or on the Continents of Europe or America.

There can be no doubt of the importance of an acquaintance, on the part of the Geologist, with the insect fauna of former times; for when we consider that insects are inhabitants not only of the air and the land, but also of the water,[1] it is obvious that a study of their remains must be of the greatest value in assisting us to arrive at just conclusions, as to the geological conditions of the earth in past ages.

The investigations and discoveries of [2]Professor Oswald Heer, of Zurich, have shown that the study of fossil insects, and a comparison of the numerical proportion existing between the *carnivorous* and *herbivorous* classes of any former period, with that existing at the present day in various parts of the world, between the same classes, cannot fail to throw much light on the nature of the vegetation and climate prevailing during former Geological epochs. The testimony of so eminent a Geologist as Sir Charles Lyell, to the valuable deductions which may be drawn from a study of fossil insects, is too important not to be here referred to. In his "Elements of Geology,"[3] Sir Charles observes that, "the characters of many of the insects" (*i.e.*, the fossil insects of Œningen) "are so well defined, as to incline us to believe that if this class of the invertebrata were not so rare and local, they might be more

[1] *i.e.*, Fresh water.

[2] "Die Insekten-fauna der Tertiärgebilde von Œningen und von Radoboj in Croatien, Leipzig, 1847-1853; Untersüchungen über das Klima und die vegetations Verhältnisse des Tertiärlandes," 1860; and a translation of the same into French by Dr. Ch. Gaudin, 1861. Die Urwelt der Schweiz, 1865, and an English translation by Mr W. S. Dallas, F.L.S., edited by Mr. Heywood, F.R.S.

[3] "Elements of Geology," 6th edition, p. 255.

useful than even the plants and shells in settling chronological points in Geology."

The fossil remains of the Vertebrata, the Mollusca, and the Crustacea, have all been carefully studied ; but notwithstanding the evident importance of fossil Entomology, it is only in comparatively recent times, that the *Insecta* have begun to receive attention. M. Emile Oustalet, after alluding to the amount of attention bestowed on the other divisions of the Animal Kingdom, observes, that although reference had been made as early as the beginning of the Eighteenth Century [1] to "*Entomolithes*," it was not until 1839 [2] that M. Brullé, in an inaugural address to the "Faculté des Sciénces de Paris," [3] called attention to the interest which might be derived from the study of fossil Insects.

It must not, however, be supposed from the foregoing observations, that this branch of Palæontology had received literally no attention whatever, prior to 1839. Reference is made to fossil insects as long ago as 1700, in Scheuchzer's "Herbarium Diluvianum ;" [4] and Marcel de Serres states that Linnæus [5] gave the name of "*Entomolithes*" to those petrifications which exhibited traces or remains of insects. In 1726 [6] a book containing descriptions of fossil insects, was published by Beringer and Hueber; this was followed in 1729 [7] by Bromell's "Lithographia Suecana ;"

[1] Signor Massalongo observes, "Fino dal principio del secolo xviii. s'ebbe contezza di insetti petrificati in varie parti d'Europa; ed il Scheuchzer prima e quindi il Sendelius furono forse i primi che ci abbiano tramandate notizie di qualche importanza sopra questi esseri." Studii Paleontologici. Verona. 1856. p. 11.

[2] "Depuis la vigoureuse impulsion donnée par Cuvier à la Paléontologie les Mamifères, les Oiseaux, les Reptiles, les Poissons, les Crustacés, et les Rayonnés eux-mêmes, aussi bien que les végétaux, ont été l'objet de travaux considérables qu'il serait impossible d'énumérer ici. Seuls les insectes ont été négligés pendant fort long temps, quoique dès le commencement du xviii.e siècle, Scheuchzer et Sendelius eussent signalé des *Entomolithes;* et ce n'est qu'en 1839 que Brullé dans une thèse inaugurale, soutenue devant la Faculté des Sciences de Paris, fit presentir l'intérêt que pouvait offrir l'étude des Insectes fossiles."—See "Recherches sur les Insectes Fossiles des Terrains Tertiaires de la France" by E. Oustalet. "Annales des Sciences Géologiques," tome 2me. art No. 3, and the "Bibliothèque de l'école des hautes études," tome iv^e., article No. 7.

[3] "Sur le gisement des Insectes fossiles, et sur les secours que l'étude de ces animaux peut fournir à la Géologie." Thèse, 1839, in 4o.

[4] "Herbarium Diluvianum." Tiguri, 1700 & 1723 edit 2 in fol. Physica Sacra.

[5] "On sait que Linné a donné le nom d' *Entomolithes* aux pétrifications qui présentent des débris ou des vestiges d'insectes." Géognosie des terrains tertiaires, &c., (p. 207), by Marcel de Serres. 1829.

[6] Lithographiæ Wirceburgensis specimen primum. Fol. Wirceburg, 1726.

[7] Lithographia Suecana. Acta Litteraria Sueciæ II. 1729.

in 1742[1] by the "Historia Succinorum," of Sendelius; and in 1779 by Schröter's "Lexicon."[2] Nothing more, worth noticing, then appeared on this subject for about 50 years, when in 1829,[3] M. Marcel de Serres produced an important work on the fossil invertebrates of the Tertiary formations of the South of France.[4]

In the same year (1829), a further contribution to our knowledge of fossil Entomology was made by the late[5] John Curtis, in a paper on the "Tertiary Formations of Aix," by Sir Roderick Murchison, and Sir Charles Lyell. The next work of any importance, which treated of this subject, was Bronn's "Lethæa Geognostica,"[6] published in 1835.

One of the most valuable works on this branch of Palæontology, and which has, perhaps, more than any other, directed the attention of Geologists to its interest and importance, is Professor Heer's "Die Insekten[7]—faunader Tertiärgebilde von Œningen und von Radoboj in Croatien." Professor Heer has done more to promote the study of this subject than any other Palæontologist, and has been justly styled, by Signor Massalongo,[8] "the Cuvier of fossil Entomology."

[1] Historia succinorum corpora aliena involventium. Lipsiæ, 1742.

Lexicon, 1779. 8. T. 2. pp 93-100.

[3] "Géognosie des terrains tertiaires, ou tableaux des principaux animaux invertébrês des terrains marins tertiaires du midi de la France." 16mo. Paris et Montpellier. 1829. See also, "Notes Géologiques sur la Provence." Actes: Linn: Soc: Bord: xiii. 1-82. 1843. See also "Notes sur les fossiles du bassin d'Aix." Ann: Sc: Nat. Vol iv., 1845.

[4] I am particularly indebted to Mr. W. S. Dallas, F.L.S., Assistant Secretary of the Geological Society, for allowing me to have access to the library of that Society, during a period of nearly 15 months, prior to the date of my election as a Fellow of the Society.

[5] See the "Edinburgh New Philosophical Journal" for October, 1829.

[6] "Lethæa Geognostica oder Abbilduugen und Beschreibungen der für die Gebirgs-Formationen bezeichnendsten Versteinerungen." By Heinrich Georg Bronn. 1835, second edit. 1838.

"Die Insekten fauna der Tertiärgebilde von Œningen und von Radoboj in Croatien." Leipzig, 1847-1853. See also, by the same author, "Zur Geschichte der Insekten." Verhandl. Schweiz. naturf. Gesellsch., xxxiv., 78-97. 1849. "Ueber die fossilen Insekten von Aix in der Provence." Vierteljahrsschr. naturf. Gesellsch. Zürich I., 1-40. 1856. "Ueber die Insekten fauna von Radoboj." Bericht 32e Versamml. Deutsch. Naturf. 118-121. 1858. "Untersüchungen über das Klima und die Vegetations Verhältnisse des Tertiärlandes." 4to. Winterthur. 1860; and translation of the same into French by Ch. Gaudin, 1861. "Die Urwelt der Schweiz," 1865; and translation of the same into English by Mr. W. S. Dallas, edited by Mr. J. Heywood.

[8] "Però fra tutti, quegli che portava al suo apogeo questa scienza fu il celebre Prof. Osvaldo Heer di Zurigo, il quale a buon dritto può vantarsi

Amongst the names of English students of, and writers on the subject, the most prominent is that of the Rev. P. B. Brodie, M.A., F.G.S., who, in 1845, with the assistance of Professor Westwood, produced the *only book*[1] on Fossil Insects which has appeared in this country.

Several short memoirs and papers on the subject, have also been written by the Rev. F. W. Hope,[2] F.R.S., Professor Westwood,[3] F.L.S., Dr. Henry Woodward,[4] F.R.S., Mr. T. Vernon Wollaston,[5] F.L.S., Mr. Arthur Gardiner Butler,[6] F.L.S., and others.

di essere il vero fondatore e riformatore di questa scienza, e deve essere salutato quale Cuvier della fossile Entomologia." Studii Palæontologici, p. 11. Verona, 1856.

[1] "A History of the Fossil Insects in the Secondary Rocks of England," by the Rev. P. B. Brodie, M.A., F.G.S. London, 1845. See also, by the same, a paper "On the Nature, Origin, and Geological History of Amber, with an account of the fossils it contains," in the report of the Warwickshire Natural History Society for 1871; also, by the same, a paper "On the Distribution and Correlation of Fossil Insects in the Secondary Rocks." Warwick, 1874.

NOTE.—Various short *papers*, *memoirs*, and *notices* on the subject of fossil insects have from time to time appeared in the "Proceedings of the Geological Society," the "Quarterly Journal of the Geological Society," the "Geological Magazine," the "Transactions of the Entomological Society of London," the "Quarterly Journal of Science," and other periodicals; but with the exception of Brodie's "Fossil Insects" (which is now out of print) no *book* has been written on this subject in this country.

[2] See a paper on "Succinic Insects," by the Rev. F. W. Hope, F.R.S., in the "Transactions of the Entomological Society of London," 1, iii., 133-147; also another paper by the same on "The Fossil Insects of Aix, in Provence," in the "Transactions of the Ent. Soc. London," iv., p. 250-255; also another paper by the same, entitled "Descrizione di alcune specie d'insetti fossili," in the annals of the "Academia degli aspiranti naturalisti" (Achille Costa).

[3] See a paper entitled "Contributions to Fossil Entomology," by Professor Westwood, M.A., F.L.S., in the "Proceedings of the Geological Society of London," Vol. x., p. 378-396. 1854. Also, by the same, "Introductory Observations to Brodie's 'History of Fossil Insects in the Secondary Rocks of England.'" 1845.

[4] See a paper in the "Transactions of the Geological Society of Glasgow," vol. ii., pt. 3. p. 234-248, by Henry Woodward, F.R.S.; also a paper by the same on "The discovery of a new and very perfect Arachnide from the Ironstone of the Dudley Coal Field," in the "Geological Magazine" for September, 1871, vol. viii., p. 385; also a paper on "A new Arachnide, &c., in the "Geological Magazine," vol. ix., No. 9, September, 1872, and in the "Geological Magazine," vol. x., No. 3, March, 1873; also a paper on "An Orthopterous Insect from the Coal Measures of Scotland," in the "Quarterly Journal of the Geological Society" for February, 1876.

[5] See a paper on "The Brick Pit at Lexden, near Colchester," in the Quart. Journ. Geol. Soc., Vol. xix., 1863, pp. 393-400, by the Rev. O. Fisher, M.A., F.G.S., with "Notes on the Coleoptera," by T. Vernon Wollaston, M.A., F.L.S.

[6] See "Lepidoptera Exotica," pp. 126-128, by Arthur Gardiner Butler, F.L.S.; also a paper by the same in the Geol. Mag., x., No. 103. 2-4.

In America, some attention has lately been devoted to Fossil Insects by Dr. Dawson,[1] Professor Dana,[2] Professor Denton, Professor Léo Lesquereux, Mr. Mead, Mr. Richardson, Dr. Horn, Mr. Meek, and by that distinguished Entomologist, Mr. Samuel H. Scudder,[3] to whose numerous writings, especially his exhaustive essay on "Fossil Butterflies," recently published in the "Memoirs of the American Association for the Advancement of Science," constant reference will be made throughout this paper.

Amongst other important contributors to our knowledge of fossil Entomology must be mentioned Burmeister,[4] Gravenhorst,[5] Charpentier,[6] Giebel,[7] Carl von Heyden,[8-15], Lucas von Heyden,[13-16]

[1] See a paper by Dr. Dawson, F.R.S., in the "Geological Magazine" for September, 1867.

[2] Sill. Journ. (2) Vol. xxxvii., p. 34.

[3] The Geological Magazine, Vol. v., April and May, 1868. "Memoirs of the American Association for the Advancement of Science." Salem, Mass., 1875. See also "Bulletin of the Geological and Geographical Survey of the Territories," Vol. ii., No. 1, and the Report of Progress, 1875-1876. Geological Survey of Canada. Proceedings of the Boston Society of Nat. Hist., vols. x., xi., and xviii. The American Naturalist, vols. i. and vi., &c.

[4] Handbüch der Entomologie. 1832-1855.

[5] "Bericht der Entomologischen Section." Ueber d. Arbeit u. Verhändl. Schlesisch. Gesellsch. 1834. 92-93.

[6] "Ueber einige fossile Insekten aus Radoboj in Croatien." Acta. Akad. Leop. Carol. xx., 401-410. 1843.

[7] Insekten reste in Wettiner Steinkohlengebirge. 1850.—"Deutschland's Petrefacten." 8vo. Leipzig. pp. 644. 1852.—"Fauna der Vorwelt," vol. ii. 8vo. Leipzig. 1856.—"Geologische Uebersicht der Vorweltlichen Insekten." Zeitschr. gesammt. Naturw. viii., pp. 174-188. 1856. —Zur fauna des Lithographischen Schiefers von Solenhofen, t. 9, p. 373-388. 1857.

[8] *Chrysobothris Veterana und Blabera avita* zwei fossile insekten von Solenhofen. "Palæontographica, vol. i., p. 99-101. 1851. (C. von Heyden).

[9] Reste von Insekten aus der Braunkohle von Salzhäusen und Westerburg. "Palæontographica," iv. pp. 198-201. 1854-1856. (C. von Heyden.)

[10] Fossile Insecten aus der Braunkohle von Sieblos. Dunker and Meyer's "Palæontographica," vol. v., pp. 115-126. 1858. (C. von Heyden.)

[11] Fossile Insekten aus der Rheinischen Braunkohle. "Palæontographica," vol. viii., 1-15. 1859-1861. (C. von Heyden.)

[12] Gleiderthiere aus der Braunkohle des Niederrheins, der Wetterau und der Rhön. "Palæontographica," vol. x., pp. 65-82, 1861-63. (C. von Heyden.)

[13] Bibioniden aus der Rheinischen Braunkohle von Rott. "Palæontographica," vol. xiv. 1865, 1866. (C. and L. von Heyden.)

[14] Käfer aus der Braunkohle des Siebengebirges. "Palæontographica," vol. xv., 1865-1868. (C. and L. von Heyden.)

[15] Fossile Insekten aus der Braunkohle von Salzhausen. "Palæontographica," vol. xiv. 1865-1866. (C. and L. von Heyden.)

[16] Fossile Dipteren aus der Braunkohle von Rott in Siebengeberge. "Palæontographica," Vol. xvii. 1867-1870. (L. von Heyden.)

Saporta,[1] Ehrenberg,[2] Pictet,[3] Geinitz,[4] Unger,[5] Bérendt,[6] Germar,[7] Goldenberg,[8] Mayr,[9] Boisduval,[10] Hagen,[11] Von Münster,[12] Massa-

[1] "Etudes sur la végétation du Sud Est de la France a l'époque Tertiare," Ann. Sc. Nat. Bot. xv., 277-351. 1872.

[2] "Inseoktes dans l'ambre" (Froriep's "Notiz," 1841, t. xix.); and Leonh. & Bronn. n. Jahrb. 1843, p. 502.

[3] "Traité élémentaire de Paléontologie," vol. iv. Geneva, 1846. See also the Paris edition, 1854.

[4] Grundriss der Versteinerungskunde, pp. 179-190. 1845-1846.
Characteristik der Kreidegebirge, p. 13.

[5] "Fossile Insekten aus Radoboj," 1839, in the Nova. Acta of the Leop. Akad. Carol., and separately in 1842.

[6] "Die Insekten in Bernstein," 1st part. Dantzig, 1830. And "Die in Bernstein befindlichen organischen Reste der Vorwelt." 1845-1856.

[7] Insekten in Bernstein eingeschlossen, &c. "Magazin der Entomologie," 1813. T. 1, H. 1, pp. 11-18.
"Fauna Insectorum Europæ." Fasc xix. of the continuation of Panzer; or separately: Insectorum protogææ specimen sistens insecta carbonum fossilium. Hallé. 1837.
Ueber die Versteinerten Insekten des Juraschiefers von Solenhofen. Isis. iv., p. 421-424. 1837.
Die Versteinerten Insekten Solenhofens. Acta. Akad. Leop. Carol., t. 19, p. 1, pp. 187-222. 1839.
Die Versteinerungen des Steinkohlengebirges von Wettin und Lôbejün. Hallé, 1844-1853.
Beschreibung einiger neuen fossilen Insekten. Münster's Beiträge. 1842. Heft 5.
1. In dem lithographischen Schiefer Baierns.
2. In Schieferthon des Steinkohlengebirges von Wettin.
Enige fossile Insekten aus der Braunkohle und dem Süsswassermergel von Aix. Zeitschrift der Deutschen Geol. Gessellchaft, t. 1, pp. 52-63. 1849.

[8] "Die fossilen Insekten der Kohlenformation von Saarbrücken." Sitzungsbericht der Kais. Akad. der Wissensch." Vienna, 1852; and in "Palæontographica" of Dunker and Meyer, Vol. iv. 1854-1856. "Neue Jahrb. für Mineralogie," &c. 1869 and 1870. And "Fauna Saræpontana Fossilis," pt. 1, 1873, and pt. 2, 1877.

[9] Die Ameisen d. Baltischen Bernstein. Königsberg, 1868.

[10] "Annales de la Société Entomologique de France," viii., Bull 11, 12; and ix., 371-374. 1839 and 1840.

[11] Entomologische Zeitung, 1846, p. 6.
Die fossilen Libellen Europas. Stett. Ent. Zeit., t. xi, p. 6-13. 1848.
Ueber die fossile odonate Stett. Ent. Zeit., t. x, 226-231. 1849.
Ueber die Neuroptern der Bernstein-fauna. Verhandl. Wein. Zool. Bot. Verein, Vol. iv, p. 221-232. 1854.
Die in Bernstein befindlichen Neuroptern, 1856. (Bérendt.)
Zwei Libellen aus der Braunkohle von Sieblos. Meyer's Palæontographica, Vol. v, p. 121-126. 1858.
P. Acutipennis aus der Braunkohle von Sieblos. Palæont., vol. viii. 1859.
A Comparison of the Fossil Insects of England and Bavaria in the Entomologist's Annual, 1862.
Die fossile Odonaten Solenhofens Palæontographica, Vol. x. 1862.
Ueber die Neuroptern aus dem Lithographischen Schiefer in Bayern-Meyer's Palæontographica, Vol. x, p. 96-145. 1861-1863.
Neuroptern aus der Braunkohle von Rott in Siebengeberge. "Palæontographica," Vol. x, pp. 247-269. 1863.
Die Neuroptern des Lithographischen Schifers in Bayern. "Palæontographica." 1866.

[12] "Beiträge zur Geognosie und Petrefacten Kunde." Bayreuth, 1814.

longo,[1] Van Bénéden,[2] Dohrn,[3] Preudhomme de Borre,[4] Adolphe[5] Brongniart, &c.

I now propose to refer briefly, in the descending order of geological succession, to the various British and Foreign formations of the Recent and Tertiary periods, in which remains of insects have been detected, and to enumerate, as far as possible, the several orders and species, to which such remains have severally been assigned.

Before doing so, it will be desirable to make a few observations on the probable circumstances, under which insects became embedded in certain strata, in which their remains have been discovered.

The estuarine and purely fresh-water formations are, as would naturally be expected, those in which the remains of insects have been found in the greatest quantities; but their remains have also been discovered, and in some cases in considerable numbers, in marine formations, such as the Stonesfield Slate of England and the Solenhofen Slate of Bavaria. Their presence in such formations, may be accounted for by supposing them to have been blown or washed out to sea from some neighbouring land, or to have been blown into the sea when attempting to cross it, and then sinking to the bottom, have become embedded in the sediments there accumulating.

It is well known to all Entomologists that insects migrate in vast armies, frequently crossing the sea to effect their purpose.

Pieris Rapæ has been known to cross the channel from France to England, in a dense swarm. On this subject an eye-witness has written—" Such was the density and extent of the cloud formed by the living mass that it completely obscured the sun from the people on board the steamer, for many hundreds of yards, while the insects strewed the deck in all directions." Mr. H. W. Bates,

1 " Studii Palæontologici. Verona, 1856.

2 Bulletins de l'Académie Royale de Belgique, 2me serie, Vol. xxiii.. pp. 384-400.

3 Zur Kenntniss der Insekten in der Primärformationem. " Palæontographica," Bd. xvi , pp. 129-136.

4 " Notes sur des Empreintes d'insectes fossiles," extracted from the " Annales de la Société Entomologique de Belgique," tome xviii. 1875.

5 Bulletins de la Société Géologique de France, tome iv, p. 459, 1876; and " Compte-Rendu de la Société Entomologique de Belgique." Série 2, No. 47. (1878).

NOTE.—No attempt is made here to give a *complete* list of the writings, on fossil Entomology, of the above-named authors. The bibliography of the subject will be dealt with at the end of the third paper.

F.L.S., in his book on the "Amazons," mentions several instances of the flights of insects over the ocean. Live beetles have been caught at sea many miles from the shore. Swarms of locusts have been observed many hundreds of miles from land, and moths, dragon flies, and other insects have alighted on the decks of vessels in mid-ocean.[1]

The occasional presence of a fossil insect in marine formations may be thus accounted for; but where insect remains are detected in any abundance in such formations, the proximity of dry land, at the time of their deposition, may be generally assumed.

Wherever insects have been discovered in a fossil state, the *Coleoptera* are generally very numerous. This is easily accounted for by the hardness and indestructible nature of their *elytra*.

It is worthy of note that the insects even from the older strata (*e.g.*, the Coal Measures), are far more closely allied to existing species than the rest of the fauna of the ancient world; and although some of them cannot be identified with any living types, still there is, as Mr. Brodie observes, "a much less proportional difference in this respect than might fairly be expected; so that these fossils may be almost said to afford an exception to the usual conclusions which have been derived upon this subject."

It is evident, from a comparison of fossil insects with existing species, and from a study of their geographical distribution, that the temperature of Europe has, during the Tertiary Period, undergone considerable changes; and the distribution of genera, and the size of species, as well as the numerical proportion existing between various groups, indicate the former existence of a warmer climate in Europe than that now prevailing in the same latitudes.

Dr. Heer has noticed that the development of insects has been, as might be expected, influenced by that of the Vegetable Kingdom; certain species not having appeared prior to the period at which dicotyledonous plants attained their highest state of development.

It has been remarked by M. Oustalet,[2] that each formation, or rather each deposit (on the continent), in which fossil insects have been detected, is characterised by the prevalence of some particular

[1] See Wallace's "Geographical Distribution of Animals," Vol. i., p. 32. 1876.
[2] Recherches sur les Insectes fossiles, p. 26.

family or order; thus the genus *Blatta* is especially well represented in the Lias of Aargau; the *Rhyncophora* in the marls of Aix; the *Buprestidæ* in the quarries of Œningen; the Ants in the sulphurous marls of Radoboj; and the *Termites* in the Baltic amber. This seems satisfactory evidence that each one of these groups found in its locality, during the period of its existence, all the essential requisites for its development.

I have a good deal to say on this subject, as well as on that of the dates of apparition of the various orders of insects on the Geological horizon; but my observations will be reserved until the end of the third paper of the series, when—having brought under review the various (insect) fossiliferous strata of the Recent, Tertiary, Secondary, and Primary Periods, and the orders, families, and species of insects which have been discovered therein—I shall be better able to draw general conclusions than I am in the introductory portion of the first paper.

I will now proceed to notice the various formations in which fossil insects have been detected, and the orders, families, and species to which such fossils have severally been referred.

In every case British strata and their fossils will be first alluded to, and then those of the Continents of Europe and America.

RECENT OR POST TERTIARY.

BRITISH STRATA.

One of the most recent deposits in this country, in which fossil insects have been detected, is that of the Brick earth at Lexden,[1] near Colchester. In a paper "on the Brick Pit at Lexden," in the "Geol. Society's Journal" for 1863, the Rev. O. Fisher states that he obtained a number of specimens of *Coleoptera* from this locality, which he submitted to Mr. T. Vernon Wollaston. Amongst these remains Mr. Wollaston identified several elytra of beetles, belonging to the following genera, viz.: *Cassida*, *Curculio*, *Coccinella*, *Chrysomela*, and *Cossyphus*. Some of these remains are referred, doubtfully, to *Carabidæ* and *Buprestidæ*. Mr. Wollaston states that, with one or two exceptions, these *Coleopterous* remains could not be referred to existing British species.

[1] On the Brick Pit at Lexden, near Colchester, Quart. Journ. Geol. Soc., Vol. xix. 1863, pp. 393-400, by the Rev. O. Fisher, M.A., F.G.S., with notes on the *Coleoptera*, by T. Vernon Wollaston, M.A., F.L.S.

In the third volume of the Geological Society's Proceedings,[1] there is a paper, by Lyell, on "the Boulder formation, or drift, and associated freshwater deposits, comprising the mud cliffs of Eastern Norfolk." This paper contains an account of the discovery in the Mundsley deposit, of the elytra of certain Beetles, especially of the genus *Donacia.* Mr. Curtis was of opinion that in these remains there were two species of *Donacia*, both possibly identical with existing British Insects. The same Entomologist has also detected, in these fossils, the presence of an *Elater*, an elytron of one of the *Harpalidæ*, also another elytron, which he confidently referred to *Copris lunaris.*

Dr. Berger,[2] in his account of the Isle of Man, speaks of finding, in diluvial deposits, a vast number of the *exuviæ* of beetles, and bees and their nests, crushed together with seed vessels.

FOREIGN STRATA.

The most recent strata on the Continent of Europe, in which fossil insects have been found, are, according to Professor Heer,[3] the Lignites and Clays of Utznach and Dürnten, in Switzerland, which he refers to the Recent or Post Tertiary period.

M. Brullé records from these deposits a *Coleopterous* insect allied to *Feronia leucopthalma*, another similar to *Callidius fennicum*, and an *Elater* referable to *Elater* (*? Harpalus*) *æneus.* Professor Heer records from the same deposits two species of *Donacia*, resembling *Donacia discolor*, and *Donacia sericea* ; and he says that their elytra lie by hundreds in some parts of the Lignite. Dr. Heer also describes a species of the genus *Hylobius* (*H. rugosus*), allied to *Hylobius pineti*, but distinct ; an existing species of the genus *Pterostichus* (*P. niger*), and two extinct species of *Carabidæ*, viz., *C. diluvianus* and *C. cordicollis.*

In the 9th volume of the "Bulletins de la Société Géologique de France," [4] M. Cordier is reported to have communicated to the Society an extract from a letter, addressed to him from Stockholm, by M. E. Robert, in which the latter stated that he had found, in the turf pits near Elsinore, remains of insects, including *Lucanidæ*, (*Cervus longirostris*), *Aphodius fossor*, two species of *Buprestidæ*, &c.

[1] Geological Proceedings, Vol. iii., p. 175.
[2] See Geol. Transactions, Vol. v., p. 501.
[3] Urwelt der Schweiz, p. 481.
[4] Bull. Soc. Geol. de France, t. ix., p. 114.

TERTIARY OR CAINOZOIC.

The very small number of fossil insects, recorded from the Tertiary formations of the United Kingdom is remarkable, especially when compared with the great number of species described from European and American Tertiary formations.

No doubt the list of species in this country will be largely increased when further investigations have been made. The insignificance of the British list may, in a great measure, be accounted for by the fact that in this country, the researches and investigations of the Rev. P. B. Brodie, Professor Edward Forbes, Mr. W. R. Brodie, the Rev. O. Fisher, Captain Woodley, and others, have principally been in the Secondary Rocks—especially in the Middle and Lower Purbecks of the Upper Oolite, and in the Lias ; whereas, on the Continent of Europe, as much attention appears to have been bestowed on the formations of the Tertiary epoch, as on those of any other ; and besides, on the Continent, investigations have been carried on for a much longer period, and by a far greater number of persons.

BRITISH STRATA.

LOWER MIOCENE.

In the list of fossil insects at the end of Mr. Brodie's paper on the " Distribution of Fossil Insects,"[1] I find recorded " Elytra of two species of beetles from the Miocene formation in the neighbourhood of Antrim, Ireland."

These beetles are also mentioned by Professor Judd, F.R.S., in his 1st paper on the " Volcanic Rocks of Scotland."[2]

[3]Mr. Pengelly, F.R.S., states[4] that when Professor Heer was in England, he devoted a few days to the deposits of Bovey Tracey, in Devonshire, and that amongst the remains from these strata he obtained one Beetle—*Buprestis Falconeri*. This insect, says Mr.

[1] See a paper on the " Distribution and Correlation of Fossil Insects, chiefly in the Secondary Rocks," by the Rev. P. B. Brodie, M.A., F.G.S., Warwick, 1874.

[2] Geol. Jourl., Aug., 1874, Vol. 30.

[3] See a paper on " The Lignites and Clays of Bovey Tracey, Devonshire," by W. Pengelly, in the Royal Society's Proceedings, Vol. xi, 1860-62.

[4] I am indebted to Professor John Morris, F.G.S., for calling my attention to this paper.

Pengelly, was the first evidence of animal life which had been obtained from these strata.

Upper Eocene.

In the December number of "Nature" for 1874, Mr. E. J. A'Court Smith records the discovery, in the Eocene shale of Gurnet Bay, Isle of Wight, of "a bed of insects, flies and gnats, and the larvæ and pupæ of the latter, the larvæ in countless thousands; also the wings, in great number, of a variety of flies, butterflies, and grasshoppers; also a wing resembling that of a mole cricket; likewise two or three beetles."

In a letter to me on the subject, dated the 8th February last, Mr. A'Court Smith says—"I regret that I am unable to furnish you with more than the orders I have recognised in the insect collection obtained from the Eocene shale of this place. *Diptera* are well represented; *Hemiptera* by one or two species; *Lepidoptera* in considerable numbers, and several species; *Orthoptera* are mainly confined to beautiful wings of grasshoppers and crickets; there are also specimens of *Hymenoptera* and *Neuroptera*. There are fully one thousand specimens of insects, more or less perfect, quite a thousand wings from the most minute—scarcely to be recognised without a lens—to very fine specimens of grasshoppers, and other *Orthoptera*."

A sample of this collection—which is by far the most important yet obtained from English Tertiary strata—is at present in the possession of Dr. Henry Woodward, F.R.S., and by his courtesy I have had an opportunity of inspecting it.[1]

[1] Since this paper was read in June last, these insect remains have been identified by Dr. H. Woodward and Mr. Frederick Smith, and they have been described by Dr. Woodward in a paper read by him at a meeting of the Geological Society, on the 19th December last. In the abstract of the proceedings of the Society at this meeting, these fossils are thus described—"The remains of Insects noticed in this paper were obtained by Mr. E. J. A'Court Smith, from a thin bed of limestone, belonging to the Osborne or St. Helen's series at Thorness and Gurnet Bay, in the Isle of Wight. The collection is the result of about 20 years' work. The insect remains comprise about fifty specimens of *Diptera*, including wings of *Tipulidæ* and *Culicidæ*, and the pupa apparently of a gnat, one wing of a *Hemipterous* insect, and a flattened *Homopterous* insect, identified by Mr. F. Smith with *Triecphora sanguinolenta*; two specimens referred to the *Lepidopterous* genus *Lithosia*; only three *Orthoptera*, one a *Gryllotalpa*, the other two belonging to a grasshopper: thirty-five *Hymenopterous* wings, thirty-three of which are referred to ants of the genera *Myrmica*, *Formica*, and *Camponotus*; twenty-three examples of *Neuroptera* referred to *Termes*, *Perla*, *Libellula*, *Agrion*, *Phryganea*, and *Hemerobius*; and twelve of *Coleoptera*, including species of *Hydrophilus*, *Dyticus*, *Anobium*, *Dorcus*, and *Staphylinus*."

Middle Eocene.

In the Geological Society's Proceedings for 1854,[1] Prof. Westwood describes and figures certain *Buprestidæ* from the Leaf beds at Creech, near Corfe, Dorset, belonging to the Bagshot series of the Middle Eocene; also Elytra of *Helopidæ* and *Curculionidæ* from the same formation.[2]

Mr. Brodie informs me that Mr. J. S. Gardner,[3] F.G.S., has recently discovered remains of insects at Bournemouth, in the Leaf Beds of the Bagshot Sands; that they consist of *elytra* of *Coleoptera*, wings of gnats and bees, *Diptera*, &c.

Lower Eocene.

In the list at the end of Mr. Brodie's paper on the "Distribution of Fossil Insects," Elytra of *Coleoptera* are recorded from "the Lower Eocene of the Isle of Wight;" and Dr. Mantell,[4] in his "Geology of the Isle of Wight," mentions that "Mr. Webster has observed traces of *Coleopterous* insects in the London Clay, near Parkhurst."

In the "Geologist" for January, 1861,[5] Mr. Caleb Evans, states that he obtained a few insect remains from the Paludina bed at Peckham. These remains were referred to Dr. Henry Woodward and Mr. Frederick Smith. Dr. Woodward was of opinion that three of the specimens were not determinable; that one was the elytron of a species of *Curculionidæ*, genus *Strophosomus*, or *Cucorhinus* (?), and another an elytron of an *Elater*.

I can find no record of the discovery of any other fossil insects from British Tertiary[6] formations.

[1] Geol. Proc., Vol. x, p. 381. See also Quart. Journ. Geol. Soc., Vol. ix. p. 53-54, 1853.

[2] In a paper in the Annals and Magazine of Natural History for 1869, Mr. Wanklyn alludes to an insect discovered by him in the Bournemouth Leaf Beds, and also adds—"Remains of Insects from the Pipe Clay of Corfe have been figured in the Quarterly Journal of the Geological Society, in a paper by Mr. Prestwich."

[3] Since this paper was written Mr. J. S. Gardner has discovered further remains of insects in the Bournemouth Leaf Beds. Many of them are in a fair state of preservation, and Mr. Gardner has been good enough to lend them me for examination.

[4] "Geological Excursions Round the Isle of Wight," by Dr. G A. Mantell, F.R.S., p. 101; and the Quart. Jour. Geol. Soc., 1853, p. 53-54.

[5] "Geologist," January, 1861, p. 39-40,

[6] At page 254 of the "Geologist" for 1858, Mr. J. Brown, of Stanway, records the occurrence of elytra of *Coleoptera* in a bed of peat at Stanway

FOREIGN STRATA.

On the Continent of Europe, discoveries of insect remains in Tertiary Strata have been made chiefly at Œningen in Switzerland; Radoboj in Croatia; Corent and Menat in Auvergne; Siebengeberge on the Rhine; Aix in Provence; and at Monte Bolca in Upper Italy. The remains of many species have also been detected in Amber from various localities, but especially from the Amber which the Baltic Sea throws up on the coasts of Prussia. It is difficult to know exactly to what geological epoch this substance should be referred. Sir Henry de la Béche was of opinion that the Prussian deposits of Lignite and Amber belong to the Tertiary rocks, and that their place was probably above the supracretaceous group.

To whatever period, however, Amber may be most properly referable, I shall in this paper treat of it, and of the insect remains detected therein, after closing the subject of the Tertiary formations.

European Strata.

Upper Miocene.

The principal deposit of this period, in which insect remains have been detected, is the great lacustrine formation of Œningen, in the valley of the Rhine, between Constance and Schaffhausen.

The Œningen strata are said to consist of a series of marls[1] and limestones, many of them thinly laminated, and which appear to have slowly accumulated in a lake, probably fed by springs, holding carbonate of lime in solution. The organic remains have been chiefly derived from two quarries, the lower of which is about 550 feet above Lake Constance, and the upper quarry is about 150 feet higher.

From these quarries Professor Heer[2] had, by the year 1861, obtained 5,081 specimens of insects, viz.:—

	Specimens.		Specimens.
Coleoptera ...	2456	Hemiptera ...	598
Neuroptera ...	882	Orthoptera ...	131
Hymenoptera ...	699	Lepidoptera ...	5
Diptera	310		

[1] See "Lyell's Elements of Geology," 6th edit., p. 248.
[2] See "Die Insekten fauna der Tertiärgebilde von Œningen und von Radoboj in Croatien." "Urwelt der Schweiz," and "Recherches sur le Climat et la Végétation du pays Tertiaire," p. 197.

This number of specimens comprised 844 species,[1] viz.:—

		Species.			Species.
Coleoptera	...	518	Hemiptera...	...	133
Neuroptera	...	27	Orthoptera	...	20
Hymenoptera	...	80	Lepidoptera	...	3
Diptera ...	...	63			

Professor Heer[2] observes, that by comparing the number of *specimens* of each order with the number of *species* of each order, we get the following average number of specimens to each species, viz.:—

Coleoptera=specimens to each species				4·7
Neuroptera	„	„	„	33·
Hymenoptera	„	„	„	8·7
Diptera	„	„	„	5·
Hemiptera	„	„	„	4·6
Orthoptera	„	„	„	6·5
Lepidoptera	„	„	„	1·7

It will be noticed that the numbers of specimens and species of the *Coleoptera* greatly exceed those of any other order.

All the most important groups of the *Coleoptera*, as well as the majority of their families, are represented in the Œningen fossils.

			Species.				Species.
The Rhynchophora comprise			108	The Chrysomelina comprise			50
„ Sternoxi	„	...	67	„ Lamellicornia	„	...	42
„ Clavicornia	„	...	55	„ Longicornia	„	...	30
„ Geodephaga	„	...	54	„ Palpicornia	„	...	22

Each family, observes Dr. Heer, contains on an average about ten species, and each genus three species; whilst at the present day, in Switzerland, each family includes about forty-five species, and each genus five. Europe, taken as a whole, contains at the present day about 7·9 species to each genus; North America, 4·4, and South America, 6·7.

Of the 844 species above mentioned about 440 are referable to 45 genera peculiar to Œningen, viz.:—

			Genera.				Genera.
Coleoptera	...	...	21	Hemiptera	...	...	11
Hymenoptera	...	...	6	Orthoptera	...	...	1
Diptera	...	...	6				

[1] For list of species, see post,—pages 325-328.
[2] Recherches sur le Climat et la Végétation du pays Tertiaire, p. 197.

In my introductory observations, I alluded to the conclusions ich might be drawn, as to the climate and vegetation of a former och, from the study of its fossil insect fauna. I will now en-avour to explain, by reference to some of the Œningen fossils, e mode in which such conclusions may be arrived at.

M. Oustalet[1] and Professor Lacordaire remind us that insects in neral, and the *Coleoptera* in particular, may be divided, according the nature of their food, into two classes, viz., into *Carnivorous* ecies and *Herbivorous* species. The proportion which one of ese classes bears to the other varies in different countries, and, cording to Professor Lacordaire,[2] the number of *carnivorous* ecies, in proportion to the number of *herbivorous* species, rapidly minishes as we approach the Equator.

M. Oustalet,[3] quoting Lacordaire, states that at the present day e proportion of *carnivorous* species of *Coleoptera* to the total mber of species of that order, in the undermentioned countries, as follows, viz. :—

IN THE NEW WORLD.

In North America	: :	1	:	4·01[4]
„ South „	: :	1	:	9·59
„ Rio Janeiro	: :	1	:	22·51

IN THE OLD WORLD.[5]

In Siberia	: :	1	:	2·90
„ Europe	: :	1	:	3·87
„ Africa	: :	1	:	5·55

Now, at Œningen, according to the discoveries of Dr. Heer, ie fossil *carnivorous Coleoptera* are, to the total number of species that order, in the proportion of 1 : 4·62, and to the *herbivorous* ecies of that order, in the proportion of 1 : 3·62; that is to say, e *carnivorous Coleoptera* were rarer in this locality, in Upper iocene times, than they are in Europe at the present day; although ey were much more numerous there than they are at the present

[1] Recherches sur les Insectes fossiles, p. 16.

[2] In his "Introduction á l'Entomologie," Vol. 2. p. 577, Lacordaire says, La proportion relative des Coléoptères, créophages diminue rapidement à esure qu 'on se rapproche de l'Equateur."

[3] Recherches sur les Insectes fossiles, p 16.

[4] In the "Recherches sur le Climat, et la Végétation du pays tertiaire," Dr. eer gives this proportion as 1 : 4, and not 1 : 4·01, as given by M. Lacordaire.

[5] See "l'Introduction à l'Entomologie," Vol. 2, chap. xiv, p. 577, by Pro-ssor Lacordaire.

day in tropical countries, especially South America. It may be inferred from the difference in the proportion existing between these two classes of the *Coleoptera*, in Miocene times, as compared with the proportion existing between them at the present day, and from the general character of the insect fauna of Œningen, that the climate of this part of Europe, during the Upper Miocene period, approached nearer to that of the tropics than at the present day; and this inference is materially strengthened by the study of the present geographical distribution of many of the genera and species of insects, inhabiting Œningen at that period.

The majority of the Œningen species belong to genera distributed at the present day, over the Old and New Worlds; and these genera are said to comprise more than two-thirds of the total number of species discovered in these strata. Dr. Heer estimates that out of 180 genera of this class, 114 belong to the *Coleoptera*. Of these 180 genera two are not found, at the present day, out of Africa (*Lepitrix* and *Gymnochila*)—two are specially American (*Anoplites* and *Naupactus*); but of the rest some are met with in Africa, Asia, and America, particularly in the last named country.

A great number of the species of this period are allied to existing American species, and very few of them belong to genera exclusively European[1]—17 genera still inhabit the old world; and eight of them, as well as the small number which are exclusively European, are still represented at the present day in the Mediterranean fauna.

On the subject of the insect fauna of this locality, Sir Charles Lyell[2] observes, "few of the genera of insects are extinct, but many of them imply a geographical distribution widely different from that now obtaining in the same part of the world."

Dr. Heer[2] found that the results furnished by an examination of the insect fauna of Œningen agreed, on the whole, with those arrived at from a study of the flora; though the character of the flora is more strictly American, and more tropical than that of the fauna.

[1] These genera (*i.e.*, those exclusively European) are *Amphotis*, *Prostemma*, *Eusarcoris*, *Heterogaster*, and *Pemphigus*. "Recherches sur le Climat," p. 203.

[2] See Lyell's "Elements of Geology," 6th edition, pp. 254-255.

[3] For a full account of Dr. Heer's deductions, see "Recherches sur le Climat et la Végétation du pays tertiaire," pp. 204-205.

To this period (Upper Miocene) Dr. Heer refers certain strata at Parschlug, in Styria, Austria; from which he enumerates 14 species of insects, viz.[1] :—

	Species.		Species.
Coleoptera	7	Hymenoptera	2
Orthoptera	2	Diptera	2
Neuroptera	1		

The classical deposits of Senigallia, in the north-east of Italy, also belong to the Upper Miocene period.

These deposits, so famous for the quantity of animal and vegetable remains detected therein, contain, says Signor Massalongo,[2] numerous impressions of insects. [3]Many beautiful specimens of insects are said to have been obtained from these beds by the Rev. F. W. Hope, but I am not aware that he ever published any description of them.

It was from these strata that Signor Procaccini-Ricci[4] obtained a considerable number of species, which afterwards formed part of the collection of Signor [5]Giuseppe Scarabelli di Imola.

Signor Massalongo[6] describes two fossil larvæ of the genus *Libellula*, which he states that he found in splitting open some slabs of stone from this locality. He has named one species *Libellula Eurynome*, and the other species *Libellula Doris*. With this exception, I have failed to meet with the description of any Fossil Insects from Italian strata of this period.

Middle Miocene.

To this period are referred the Marls of Radoboj, in Croatia, which have been productive of a great quantity of insect remains.

[1] See "Recherches sur le Climat et la Végétation du pays tertiaire," p. 197.

[2] "Le classiche gessaje del Sinigalliese rese celebri, per le copiose reliquie di esseri organizzati appartenenti tanto al regno animale che vegetale, racchiudono anche non rade impronte di insetti." "Studii Palæontologici," Verona, 1856, p. 22.

[3] Mr Brodie informs me that the insects collected by Mr Hope from Senigallia, are in the Taylor Gallery, at Oxford.

[4] I have not been able to find any description of these fossils in the only work of Signor Procaccini-Ricci's to which I have had access.

[5] In op. cit. Massalongo says, "Voglio sperare che il mio amico Giuseppe Scarabelli che si è arricchito della raccolta del defunto Procaccini-Ricci, vorrà quanto prima fare di pubblica ragione la bella serie di insetti petrificati di questo luogo, dei quale è possessore."

[6] "Studii Paleontologici," pp. 22 and 23, plate 1, figs. 8-13.

[1]Professor Unger was the first author who published, (in 1839) on the fossil insects of this locality, a memoir of any importance. This was followed, in 1843, by a paper by [2]Von Charpentier (in the Acta. Akad. Leop. Carrol.). Since then[3] Professor Heer has thoroughly studied the fossil insect fauna of Radoboj, in which he has recognised a great number of tropical forms, including some gigantic *Termites*.

Of the insects from this locality, 312 species have been determined, viz. :—

		Species.			Species.
Coleoptera about	...	42	Lepidoptera about	...	8
Orthoptera „	...	13	Diptera „	...	83
Neuroptera „	...	20	Hemiptera „	...	61
Hymenoptera „	...	85			

The *Coleoptera* are comparatively rare, and most of the species are only represented by individual specimens ; but the [4]ants are represented by 57 species, of one of which (*Formica occultata*), Dr. Heer is said to have obtained 594[5] examples. [6]Sir Charles Lyell observes of this locality—" The insect fauna is very rich, and, like the plants, indicates a more tropical climate than do the fossils of Œningen. There are 10 species of *Termites*, some of gigantic size, and large dragon flies with speckled wings like those of the Southern States of North America; there are also grasshoppers of considerable size, and even the *Lepidoptera* are not unrepresented."

The first species (*E. atava*) of this order, *i.e.*, *Lepidoptera*, was first described by Von [7]Charpentier, and referred by him to the genus

[1] "Fossile Insekten aus Radoboj." Verhandl. der Kais. Leop. Akad. der Naturforscher, t. 19, pp. 412-428.

[2] Uber einige Fossile Insekten aus Radoboj in Croatien, "Acta Akad. Leop. Carol.," vol. 20, p. 401-410. 1843.

Von Charpentier describes 7 species, including one *Lepidopterous* Insect, which he referred to the genus *Sphinx*, but which has subsequently been identified as a butterfly, *i.e.*, *Eugonia Atava*.

[3] Die Insekten fauna der Tertiärgebilde, &c.; also "Ueber die Insekten fauna von Radoboj." Bericht 32e. Versamml, Deutsch. Naturf. 118-121. 1858.

[4] See "Recherches sur le Climat et la Végétation du pays Tertiaire," p. 197.

[5] So says M. Oustalet, but Dr. Heer, in his "Recherches sur le Climat," says 500.

[6] Lyell's "Elements of Geol.," p. 243. See also "Recherches sur le Climat," p. 205.

[7] "Acta Akad. Leop. Carol," xx., 408.

Sphinx. Dr. Heer[1] refers it to the genus *Vanessa*; but Mr.[2] Scudder places it in the genus *Eugonia*, "the position," he says, "dubiously assigned to it by Kirby, in his 'Synonymic Catalogue.'" The genus to which Mr. Scudder refers this fossil is represented equally in Europe and America.

The second species, [3]*Mylothrites Pluto*, is described by Heer, and referred by him to the genus [4]*Vanessa*. It is also described and figured by Sir Charles Lyell, who observes—"In one instance, the pattern of a butterfly's wing has escaped obliteration in the marlstone of Radoboj; and when we reflect on the remoteness of the time from which it has been faithfully transmitted to us, this fact may inspire the reader with some confidence as to the reliable nature of the characters which other insects, of a more durable texture, such as the beetles, may afford for specific determination." Mr. W. H. Edwards,[5] of Western Virginia, in his work on American butterflies, expresses an opinion that this species ought to have been referred to the genus *Argynnis*. I have carefully examined the species of this genus, which Mr. Edwards considers the nearest living representative of the fossil species *Pluto*, in the collection of the British Museum; but I fail to trace in it any but a very superficial resemblance to the latter, of which it is nearly double the size. My friend Mr. Butler[6] refers it to the genus *Junonia*, but Mr. [7]Scudder states that the new drawing of the fossil, which he received through his friend Herr Brunner von Wattenwyl, leaves little doubt that the insect is a *Pierid*, and belongs to some genus intermediate between *Mylothris* and *Hebomoia*; and he describes and figures the insect as *Mylothrites Pluto*. The remains of this insect are particularly interesting, as belonging to an extinct genus whose nearest living representatives, according to Scudder,[8] "are to be looked for in the genera *Mylothris* and *Hebomoia*. the former of which finds its highest development in torrid Africa, while the latter is confined to the Indo-Malayan Austro-Malayan regions."

1 "Die Insekten fauna," &c., 2, pp. 177-79.
2 Scudder's "Fossil Butterflies," pp. 41-44.
3 "Die Insekten fauna," &c., 2, pp. 179-82.
4 "Recherches sur le Climat,' &c., p. 205, Dr. Heer says, "corresponds with *Vanessa Hadena* of India." See also Lyell's "Elements of Geology," 6th edit., p. 243.
5 "Butterflies of North America," by W. H. Edwards.
6 "Lepidoptera Exotica," pp. 127, 128, by Arthur Gardiner Butler.
7 Scudder's "Fossil Butterflies," 45-51.
8 Op. cit., p. 78.

[1]The remains of the third and last species from Radoboj, *Pontia Freyeri*, are also described by Heer and Scudder. The genus is a modern one, which is well represented by existing species, especially in the old world.

LOWER MIOCENE.

From the lower Molasse[2] of Switzerland, Professor Heer enumerates 33 species of insects, viz. :—

	Species.		Species.
Coleoptera	26	Diptera	1
Neuroptera	2	Hemiptera	3
Hymenoptera	1		

The [3]lignites called Brown Coal, in Germany, belong for the most part to this period (Lower Miocene), and are often rich in insect remains.

The lignites of Rott, in Siebengeberge, near Bonn, are the best known. From these lignites about 29 species of insects had been recorded by the year 1856, according to Bronn,[4] Germar,[5] and Giebel.[6] These 29 species[7] were distributed amongst the undermentioned orders as follows, viz. :—

	Species.		Species.
Coleoptera	18	Diptera	5
Hymenoptera	2	Orthoptera	1
Lepidoptera	1	Hemiptera	2

In 1859,[8] Carl Von Heyden describes 21 additional species from this locality, viz. :—

	Species.		Species.
Coleoptera	12	Lepidoptera	1
Hemiptera	1	Diptera	5
Hymenoptera	2		

1 "Die Insekten Fauna," &c., 11, 182-183; and Scudder's "Fossil Butterflies,' pp. 54-56 and 78.

2 See "Recherches sur le Climat et la Végétation du Pays Tertiaire," pp. 196-197.

3 Lyell's "Elements of Geology,' 6th edit., p. 244.

4 "Lethea Geognostica," Vol. ii., p. 811.

5 "Insectorum Protogeæ Specimen, &c.," in the "Fauna Insectorum Europæ," and "Zeitschrift der Deutschen Geol. Gesellschaft,' 1, p. 52.

6 "Zeitschrift fur die Gesammte Naturwissenschaft," viii., 1856, s. 184; and in "Fauna der Vorwelt." 8vo. Leipzig, 1856.

See also "Recherches sur les Insectes Fossiles," &c., E. Oustalet; and "Traité élémentaire de Paléontologie," by F. J. Pictet, Vol. iv., pp. 92-113.

7 For a list of species, see post,—pages 330-333.

8 "Fossile Insekten aus der Rheinischen Braunkohle," Dunker and Meyer's "Palæontographica," Vol. viii., 1-15.

The subsequent investigations of Professor Heer,[1] Dr. Hagen,[2] and Herren Carl von Heyden and Lucas von Heyden,[3] raised the number of species from Siebengeberge to 180, viz.:—

[1][3] Coleoptera	92 species	([1] 32 in Heer's list). ([3] 60 described by Carl and Lucas von Heyden)
[1] Orthoptera	1 „	(in Heer's list).
[2] Neuroptera	12 „	([2] 10 described by Hagen). (2 in Heer's list).
[1] Hymenoptera	3 „	(Heer's list).
[1] Lepidoptera	2 „	„ „
[1] Hemiptera	5 „	„ „
[1] Diptera	65 „	([1] 12 in Heer's list). ([4] 23 described by C. and L. von Heyden). ([5] 30 described by L. von Heyden).

It will be noticed that only two Lepidopterous insects are enumerated from this locality. One of them is a butterfly, described by Carl Von Heyden as *Vanessa Vetula.*[6] Of this fossil Mr. Scudder[7] observes, "The single fossil represented by Von Heyden, under the name of *Vanessa vetula*, is preserved on a greasy, dark brown, thin and exceedingly fragile sheet of 'brown coal,' and is likely to become so affected by weathering as to be quite undistinguishable in the course of time." Mr. Scudder further observes that *Vanessa vetula* is the only butterfly yet found from the horizon of the aquitanian or Lower Miocene, and that it is closely related to *Thanaos*, a genus belonging to the North temperate zones of both hemispheres. The genera adjacent to *Thanaos* are said to be purely American, although tropical or subtropical, and therefore this species "looks towards subtropical North America for its relatives of the present day."

In the 10th vol.[8] of Meyer and Dunker's Palæontographica

[1] "Recherches sur le Climat et la Végétation du pays Tertiaire." p. 197.

[2] "Neuroptern aus der Braunkohle von Rott in Siebengeberge." "Palæontographica," Vol. x, 1861-1863, pp. 247-269 (10 out of the 12 species are here described by Dr. Hagen.)

[3] "Käfer aus der Braunkohle des Siebengeberges," Meyer and Dunker's "Palæontographica," Vol. xv., 1866.

[4] "Bibioniden aus der Rheinischen Braunkohle von Rott," "Palæontographica," Vol. xiv., 1865.

[5] "Fossile Dipteren aus der Braunkohle von Rott in Siebengeberge." "Palæontographica," Vol. xvii., p. 237-272 (1867-1870).

[6] "Fossile Insekten aus der Rheinischen Braunkohle." "Palæontographica," Vol. viii., 12-13. Taf. 1, fig. 10. 1859.

[7] Fossil Butterflies, p. 63, plate 3, figs. 12-16.

[8] Palæontographica, Vol. x (1862) S. 62-82.

(1862) 31 further species of insects are described from the lignites or brown coal of the Nether-Rhine and the Rhone, viz.:—

	Species.		Species.
Coleoptera	20	Neuroptera	1
Orthoptera	1	Lepidoptera	1
Hymenoptera	3	Diptera	5

Amongst other deposits of brown coal, in which fossil insects have been detected, may be mentioned those of Von Sieblos, Stöschen, and Salzhausen, from which Dr. Hagen,[1] Carl von Heyden,[2] and Lucas von Heyden, describe about 34 species, including some gigantic *Neuroptera*.[3]

The total number of species from the lignites or brown coal of the Rhine and the Rhone, which had been determined by the year 1863, amounted, according to Dr. Hagen,[4] to 103. Since that date 142 further species have been obtained from the same deposits, giving us up to the year 1870, a total of 245 species distributed among the undermentioned orders, as follows:—

Coleoptera	126 species	(69 described by C. & L. Von Heyden, *i.e.* 60 from Siebengebirge & 9 from Salzhausen.)
Orthoptera	6 „	
Neuroptera	16 „	(14 described by Dr. Hagen).
Hymenoptera	8 „	
Lepidoptera	3 „	(one of these is Vanessa Vetula).
Hemiptera	10 „	
Diptera	76 „	(25[5] described by C. & L. Von Heyden). (30[6] „ „ L. von Heyden).
	245	

During the last seven years, numerous additions *may* have been

[1] See Hagen's papers on "Zwei *libellen* aus der Braunkohle von Sieblos," and on "*Ascalaphus proavus* aus der Rheinischen Braunkohle," in "Palæontographica," Vol. v., taf. xxiv; and on "*Petalura Acutipennis*," in "Palæontographica," Vol. viii.

[2] See Von Heyden's papers on "Fossile Insekten aus der Braunkohle von Sieblos," in "Palæontographica," Vol. v.; and on "Fossile Insekten aus der Rheinischen Braunkohle," Vol. viii.

[3] *Heterophlebia jucunda, Lestes vicina, Ascalaphus proavus, &c.*

[4] See "Neuroptern aus der Braunkohle," &c., in Palæontographica, vol. 10, 247-269 In this memoir, Dr. Hagen says, "Es sind also aus der Braunkohle des Niederrhein's, der Wetterau, und der Rhön 57 Coleoptera, 6 Orthoptera, 2 Neuroptera, 8 Hymenoptera, 3 Lepidoptera, 7 Hemiptera, 20 Diptera im ganzen 103 arten bekannt."

[5] Carl Von Heyden and Lucas Von Heyden in vol. xiv. of "Palæontographica" (1865-1866) describe 12 species of insects (including two Diptera) from Salzhausen.

[6] Lucas Von Heyden describes 30 further species of Diptera from the brown coal of Rott in "Palæontographica," Vol. xvii., 1867-1870, pp. 237-272.

made to this list; but if they have, I have been unable to find any record of them.

To this period (Lower Miocene) are referred the freshwater formations of Auvergne, in Central France. These formations are, in some places,[1] partly composed of that remarkable form of limestone called "indusial," from the cases or *indusiæ* of the Caddis worms, or larvæ of *Phryganea*, great heaps of which have been encrusted as they lay, by carbonate of lime, and formed into a hard travertin. These Caddis worms are abundant at the bottom of freshwater streams and lakes, and many of the freshwater limestones of this locality are, according to Dr. Mantell,[2] almost wholly composed of these cases cemented together by calcareo silicious matter into stone, which is much employed for building purposes. "If we consider," says Mr. Scrope,[3] "that repeated strata of five or six feet in thickness, almost entirely composed of these tubes (cases), once extended over a district presenting a surface of many hundred square miles, we may have some idea of the countless myriads of minute beings which lived and died within the bosom of that ancient lake."

Professor Pictet seems to entertain some doubt as to whether the tubes or cases, before mentioned, of which the indusial limestone is in a great measure composed, were formed by larvæ of *Phryganea* or Caddis worms. He says these tubes are much thicker than those formed by *Phryganea*; the internal cavity is much smaller; and they are,[4] besides, much longer, and more resemble the tubes formed by certain *Annelida*.

M. Oustalet has recently made a special study of the fossil insect fauna of Auvergne, and has published on the subject a most important memoir,[5] (a copy of which he has presented to me) only

[1] See Lyell's "Elements of Geology," 6th edit., pp. 223-225.

[2] "The Medals of Creation," vol. ii., pp. 557-9.

[3] "The Geology of Central France," by G. Poulett Scrope, 1827.

[4] "Quelques auteurs attribuent a des larves de *Phryganes* des tubes que l'on trouve dans certains terrains d'eau douce du midi de la France. Ces tubes formés de grains de sables, ou de petits coquilles agglutinées, ne me paraissent en aucune manière pouvoir être considérées comme faits par des larves de ce genre. Ils sont beaucoup plus épais que tous ceux que forment les *Phryganes* actuelles; la cavité interne est beaucoup plus petite; ils sont d'ailleurs plus longs, &c. Ils ressemblent plus aux tubes que se font certaines Annélides." "Traité élémentaire de Paléontologie," vol. iv., p. 108.

[5] Recherches sur les Insectes fossiles des Terrains Tertiaires de la France ("Bibliothêque de l'école des hautes études," and in the "Annales des Sciences Géologiques") Paris, 1871.

equalled, in my opinion, in importance by Professor Heer's great work on the Insect fauna of Œningen and Radoboj.

The localities in this part of France, in which the majority of these fossils have been discovered, are Corent, Menat, and St. Gerand le Puy. From these localities, M. Oustalet states, that he has studied not less than 100 specimens in the collections of M.M. Lecoq and Fouilhoux, and in that of the Museum of Natural History at Paris, or collected by himself during his travels in Auvergne. These specimens comprise some 49[1] species, distributed amongst the undermentioned orders in the following manner, viz.:—

	Species.		Species.
Coleoptera	10	Hymenoptera	2
Orthoptera	1	Diptera	30
Neuroptera	5	Lepidoptera	1

The entire absence of any *Hemiptera* from this list is as remarkable as the extraordinary number of the *Diptera*.

M. Oustalet[2] observes that this last feature strikes us equally in the fauna of Radoboj, in that of Aix in Provence, and especially in that of the lignites of the Rhine, where the two genera *Bibio* and *Protomyia* constitute a large majority. The Ants, which are represented at Radoboj by 57 species (of one of which alone 500 specimens have been discovered), are entirely absent from Corent. The larvæ of the genus *Libellula* are also very rare there, whilst they form entire slabs[3] in the Œningen deposits. Next to the *Diptera* the *Coleoptera* are the best represented.

The fossil fauna of Auvergne, which have been studied by M.M. Pomel Aymard, Alphonse Milne-Edwards, and others, comprises both European and South American forms. The Reptiles, in particular, are said to have a more decided affinity, than animals of the other classes, with South American species of the present day. The insects, remarks M. Oustalet, form no exception to this rule, and include, like the other classes of the fossil fauna of Auvergne, both indigenous and exotic types; although, perhaps, the majority of the species are referable to existing European genera, there are many others whose nearest living allies are now

[1] 44 of these species are from Corent, three from Menat, and two from St. Gerand le Puy.

[2] "Recherches sur les Insectes fossiles," pp. 160-161.

[3] "Recherches sur le Climat et la Végétation du pays tertiaire," p. 197.

comprised in the fauna of Brazil. M. Oustalet further remarks that at Corent, as at Aix and Œningen, the Entomological fauna is in character partly American and partly Mediterranean; and that it may be fairly assumed that the land and freshwater conditions of Auvergne, during the Miocene period, were similar to those of Brazil at the present day; and that this part of France enjoyed, at the commencement of the Miocene or Middle Tertiary period, a climate only slightly colder than that now prevailing in Brazil.

The most recent discovery of fossil insects in this part of France has been made by[1] M. Ch. Brongniart, who, in the "Bulletin de la Société Géologique de France" for the year 1876, described a new species of a *Dipterous* insect, which he has referred to the genus *Protomyia*, and named *P. Oustaleti*, in recognition of the very important contributions to our knowledge of the fossil insect fauna of France, made by M. Oustalet. The genus *Protomyia* of Heer, observes M. Brongniart, contains no living representatives, although it was numerously represented during the Tertiary period, nearly 40 species referable to it having been described by Dr. Heer, C. and L. Von Heyden, and M. Oustalet.

According to M. Brongniart, this new species was discovered in the calcareous marl of the inferior Miocene formation of Chadrat, in Auvergne: and it differs from all previously described species in the distribution of the nervures, and appears most closely allied to *P. Joannis* and *P. Bucklandi*.

Upper Eocene.

Nowhere in the continental formations of this period, with the exception of Œningen, have fossil insects been discovered in greater abundance than at Aix, in Provence.

The town of Aix, according to [2]Dr. Mantell, is situated in the lowest part of a deep valley, the immediate flanks of which are composed of a thick freshwater formation, lying unconformably upon strata of Jura limestone. The freshwater series consist of white and grey calcareous marls, calcareo-siliceous grits, and beds of gypsum.

[1] "Bulletins de la Société Géologique de France," tome 4$^{me.}$ p. 459, (1876).

[2] See "The Medals of Creation," Vol. ii., p. 557; also a paper on "The Tertiary Freshwater Formations of Aix, in Provence," by Murchison and Lyell, in the "Edinburgh New Philosophical Journal" for October, 1829.

M. Marcel de Serres[1] was the first to make known to the scientific world the occurrence of insects in these gypseous marls.

In his [2]"Géognosie des terrains tertiaires" he enumerates about 80 genera from this locality, comprising the following, viz.:—

	Genera.		Genera.
Coleoptera	20	Hymenoptera	9
Orthoptera	6	[3] Lepidoptera	4
Hemiptera	14	Diptera	20
Neuroptera	2		

The insects included in these genera were said by Marcel de Serres to be all of European forms, and [4]to be mostly referable to species still existing.

A number of insects from this locality (including some 45 species) collected by Murchison and Lyell,[5] were described by Mr. Curtis in 1829. They consisted principally of *Diptera*, *Hemiptera*, and *Coleoptera*, with a few *Hymenoptera*, and one *Lepidopterous* insect. According to Curtis, several of the beetles had their wings extended beyond the *elytra*, as if they had been flying, and had dropped; and a *Chrysomela* had the *elytra* expanded, from which it would appear that it had fallen upon the water and been drowned. Other insects appear to have been imbedded whilst in repose, or when walking.

Some eight years later, when [6]Bronn published his "Lethæa Geognostica," a great number of other insects appear to have

[1] See "Bulletin des Sciences," Vol. viii., p. 181 (No. 15), also "Géognosie des terrains tertiaires," &c., pp. 220-2.

[2] See "Traité élémentaire de Paléontologie," by F. J. Pictet, Vol. iv., pp. 100-14.

[3] "*Papilio* de la division, '*Satyrus*.' *Zygæna*: une éspèce peut-être de ce genre, mais faute de caractères positifs il est bien incertain que notre insecte s'y rapporte. *Sesia*; une espèce voisine de la *Sesia vespiformis*. Une autre espèce moins allongée a corps, plus gros et à peu près de la stature de la *Sesia brosiformis* d'Hubner. *Bombyx*; un *Lepidoptere* nocturne du genre *Bombyx* ou *Cossus*." Géognosie des terrains tertiaires, &c., p. 230. Marcel de Serres.

[4] "Il est donc certain que les débris d'insectes fossiles du bassin d'Aix se rapportent uniquement à des espèces Européennes et même la plupart, a ce qu'il parait, à des espéces qui vivent encore dans nos contrées méridionales." *Op. cit.*, p. 233

[5] See the "Edinburgh new Philosophical Journal" for October, 1829, pp. 287-297; also the "Quarterly Journal of Science" for September, 1828; also the "Geological Proceedings," Vol. 1, p. 151, and Vol. iii., p, 505.

[6] See "Lethæa Geognostica,," Vol. ii., p. 811.

been discovered in this locality, for in the second vol. of the last-named work the following are enumerated:—

		Genera.			Genera.
Of the Coleoptera	...	33	Neuroptera	... ...	2
Orthoptera ...	...	6	Hemiptera	... ...	17
Hymenoptera ...	...	9	Diptera	... ...	22

besides the four *Lepidoptera* mentioned by Marcel de Serres.

By the year 1844 the researches and investigations of the Rev. F. W. Hope, F.R.S.,[1] in this locality, had raised the number of genera enumerated by Marcel de Serres, Curtis and Bronn, to 113, for some 20 of which we are indebted to Mr. Hope.

For some years after the date of Mr. Hope's paper, the fossil insects of Provence, which had for a time attracted a considerable amount of attention from Geologists and Palæontologists, remained unnoticed, until, in 1851,[2] Professor Heer commenced to study them. In addition to the specimens he himself obtained during a tour in Provence, he was enabled to study those in the collection of M. Blanchet, of Lausanne, and those collected by Sir Roderick Murchison in 1829. M. Oustalet observes that, from a study of these fossils, and a comparison of their species with those found in the strata of Œningen and Radoboj, combined with the study of the fossil flora of these strata and those of the Swiss and German localities, Professor Heer was enabled to arrive at most interesting conclusions on the climate and conditions of life prevailing at that era of the Tertiary period in various countries of central Europe.

Of the 60 fossil species from the marls of Aix, contained in the collections above mentioned, Dr. Heer states that nine have been found at Radoboj, and four at Œningen; that is to say that at Radoboj twice as many species are found in common with Aix as at Œningen, although this last locality is much nearer Provence, and possesses a much richer fauna, and consequently offers many

[1] See a paper entitled "Observations on the Fossil Insects of Aix, in Provence," by the Rev. F. W. Hope, F.R.S., in the iv. Vol. of the "Transactions of the Entomological Society of London," pp. 250 255. Also, by the same, "Descrizione di alcune specie d'insetti fossili," in the Annals of the "Acadmia degli aspiranti Naturalisti," December, 1847.

NOTE.—This memoir appears to have been written by Mr. Hope in French, and to have been translated into Italian by Signor Achille Costa, who added to it some observations in parenthesis.

[2] "Ueber die fossilen Insekten von Aix in der Provence," Vierteljahrsschr naturf. Gesellsch, Zürich I., 1-40. 1856.

more points of comparison. Even those species which are not common to both Radoboj and Aix, but are confined to the last locality, are most intimately connected with those of the former. M. Oustalet remarks that at the time at which Dr. Heer was writing, the exact geological position of the gypseous marls of Aix had not been determined, but that they were regarded as contemporaneous with those of Montmartre, belonging to the Ligurian or Upper Eocene. From his study of their fossil insects Dr. Heer was of opinion that the geological position of these marls should have been somewhat higher up—nearer the marls of Radoboj in the Miocene formation.

Dr. Heer's conclusions, derived almost solely from an investigation of the fossil insects of the district, have, says M. Oustalet, since been to a great extent confirmed by the majority of Geologists, who have subsequently studied this formation ; and although the strata have not been referred to the same period as the marls of Radoboj, they have been placed nearer to them, at the base of the Miocene period, almost on a level with the sandstone grit of Fontainbleau.

M. Marcel de Serres[1] stated, as I have before observed, that the majority of the fossil insects of Aix belonged to existing European forms, and he concluded from this that the geological conditions of Aix during the Upper Eocence period were similar to those of the present day.

The conclusions of Marcel de Serres, observes M. Oustalet,[2] are far from being, in all respects, confirmed by recent observations ; for whilst admitting that the fossil fauna of Provence contains a number of types, if not identical with, at least closely allied to those now inhabiting the Mediterranean basin, it also contains several forms which, at the present day, are only represented in the south of Africa, in Asia, and America.

According to Count Saporta,[3] the fossil flora of the Aix district has a more southerly character than even the fauna ; and it may be safely inferred from its fossil fauna and flora that the climate of Aix, at the end of the Eocene and commencement of the Miocene period, more nearly approached that of the tropics than at the present day.

One of the most remarkable facts connected with the Aix

[1] "Géognosie des Terrains Tertiaires," &c.
[2] "Recherches sur les Insectes fossiles," &c., pt. 2, p. 6.
[3] "Etudes sur la Végétation du sud-est de la France à l'epoque Tertiaire," 1872.

formations, and which has perhaps served to render them more interesting to Entomologists than any others from which fossil insects have been obtained, is that of the *nine* well authenticated fossil butterflies from the Tertiary formations, *five*[1] of them have been found here. Of these five species, the first discovered, and the best known is *Neorinopis sepulta*,[2] the earliest notice of which is given by Marcel de Serres in the "Annales des Sciences Naturelles" for 1828. Mr. Scudder, who has figured and described the insect,[3] states that the earliest definite mention of it is given by Duponchel, in the [4]"Bulletin de la Société Entomologique de France," in the following words:—"M. Duponchel entretient ensuite la Société d'un fait extraordinaire, et peut être entierement nouveau dans les annales de la Science. C'est l'existence d'une impression très remarquable de Lépidoptère fossile, qui a été trouvée dans une plâtrière des environs d'Aix, et acquise par M. de Saporta." This fossil was subsequently described and figured by Dr. Boisduval.[5] Mr. Butler has referred the species to the *Satyridæ*, and has described and figured it in his "Lepidoptera Exotica."[6]

The second fossil butterfly from these formations is described, for the first time, by Mr. Scudder as *Lethites Reynesii*.[7] It does not, in his opinion, belong to any existing European genus, and he mentions *Maniola Hermione* as its nearest ally among living European species. This fossil was detected by Mr. Scudder in the Museum at Marseilles, and named by him, after Dr. Reynès, the Director of that establishment. It appears to have been previously overlooked.

The third butterfly from Aix[8] is in the collection of Count Saporta,[9] and has been described and figured by Scudder, and named by him

[1] See Scudder's "Fossil Butterflies," p. 83.
[2] See the last mentioned work, p. 14; also "Les Annales des Sciences Naturelles" for 1828, and the "Géognosie des Terrains Tertiaires." See also "Ueber die fossilen insekten von Aix in der Provence," Vierteljahrsschr naturf. Gesellsch. Zurich. 1, pp. 1-40, 1856.
[3] See Scudder's "Fossil Butterflies,' p. 14.
[4] Bulletins de la Société Entomologique de France, 1838, 51-52.
[5] Annales de la Soc. Ent. de France, ix., 371-4.
[6] See "Lepidoptera Exotica,' plate 48, fig. 3 (1873), also Geol. Mag. Vol. x. 3, plate 1, fig. 3 (1873).
[7] See Scudder's "Fossil Butterflies," p. 37; also Révue et Magasin de Zoologie, 1871-2, pp. 66-72; also Geological Magazine, Vol. ix., 532-33.
[8] See Scudder's "Fossil Butterflies," pp. 51-53.
[9] Mr. Scudder, at page 70 of his "Fossil Butterflies," says, "Count Saporta writes me concerning this fossil, 'Cette empreinte ne provient pas des platrières même, c'est a dire les galeries qui servent à l'exploitation du Gypse; *mais d'une assise ou groupe des couches immédiatement inferieure*."

Coliates Proserpina. It appears to have been discovered in the strata immediately beneath the calcareous marls of the gypsum quarries, and is therefore the *oldest butterfly* from the *Tertiary* formations.

The fourth insect of this order from these deposits—*Thaites Ruminiana*—was first described by Professor Heer,[1] who observes of it, "closely allied to the genus *Thais* which belongs to the Mediterranean fauna." It is in the collection of Professor Heer, and has since been described and figured by Mr. Scudder.[2]

The remains of the fifth and last butterfly from the Tertiaries of Aix consist of a single forewing, which Mr. Scudder refers to some species belonging to the *Astyci.* Mr. Scudder describes the species as *Pamphilites abdita,*[3] and its remains are said to be in the Marseilles Museum.

It will be noticed that the remains of all the fossil butterflies, at present discovered, have been found at Radoboj, Rott, and Aix, *all* belonging to the Tertiary formations; that the remains of three species belong to the *Mayencian* or lower portion of the Middle Miocene; the remains of one species to the lignite beds of Rott, belonging to the *Aquitanian* or upper part of the Lower Miocene; and the remains of the other five species from the calcareous marls (or strata immediately below the same) of the gypsum quarries of the *Ligurian*, belonging to the Upper Eocene formation. It is, as Mr. Scudder observes, rather extraordinary that the Upper Miocene beds of Œningen—which, if we except the Amber, have furnished almost more insects than *all* the other formations of the world together, and which are more recent than any of those in which butterflies have been found—have yielded the remains of only one species of *Lepidoptera*, and none whatever of butterflies.

Three out of the *five* species whose remains have been discovered in the Eocene formations at Aix, are said to be now only represented in the Indo-Malayan regions; *one* is closely related to genera now found in the American tropics; and *one* is now represented by a genus confined to the Mediterranean district, within which Aix lies, and is therefore, as Mr. Scudder observes, "at home in its own resting place." One point of especial interest in relation to these butterflies, to which Mr. Scudder calls attention,

[1] Described by Heer in manuscript; see also "Recherches sur le Climat et la Végétation du pays Tertiaire," p. 205.
[2] See Scudder's "Fossil Butterflies," pp. 60-62.
[3] See Scudder's "Fossil Butterflies," pp. 66-69.

is that in every case, except one, the remains of the plants, which in all probability served their larvæ for food, have been found in the same beds as the insects themselves; and even in this excepted instance, a plant allied to those upon which species of the genus now feed, is said to occur in the same strata.

The most recent investigations of the geological strata of this district, and their fossil insects, have been made by M. Oustalet; who, in 1874, published the result of his investigations in the second part of his "Recherches sur les Insectes fossiles des Terrains Tertiaires de la France." In this most important work (a copy of which I have had the honour of receiving from the author) M. Oustalet has expressed his intention of making as complete a study of the fossil insects of Provence, as Dr. Heer has of those of Œningen.[1] Some idea of the magnitude of the labours which M. Oustalet has undertaken may be formed from the fact, that although the work above mentioned contains some 347 pages, exclusive of six plates, the *Coleoptera* only are included in it. Of the insects of this order upwards of 80 species, referable to 13 families, are described and figured.

The *Carabidæ* are represented by 11 species, the *Staphylinidæ* by 19 species, the *Curculionidæ* by 32 species, and the *Chrysomelidæ* by 7 species.

With the exception of "the learned Zurich Professor," no other Palæontologist on the Continent of Europe has produced any works on this branch of science of greater importance than those of M. Oustalet.[2]

[3] M. Henri Daudet has recently obtained from the Aix deposits, a fossil larva of one of the *Satyridæ*, which he has named *Satyrites incertus*.

Middle Eocene.

To this period belong the marls and limestones of Monte Bolca, near Verona, in Italy.[4] Associated with these marls and lime-

[1] "C'est ce que M. Heer a fait pour les Insectes d'Œningen et c'est ce que j'èssayerai de faire dans le chapitre suivant, pour les Insectes des gypses de la Provence, en suivant la voie qui a été si brillament tracée par le savant Professeur de l'Université de Zurich." "Recherches sur les Insectes fossiles," &c., pt. 2, p. 74.

[2] M. Oustalet is, I believe, now engaged on a description of the fossil insects of other orders from the same district.

[3] "Revue et Magasin de Zoologie." 3e Série T. 4e 1876, p. 415-424. See also "Petites Nouvelles Entomologiques," No. 145.

[4] See Lyell's "Elements of Geology," 6th edit., p. 687.

stones are beds containing lignite and shale, which have been described by Professor Unger and Signor Massalongo, and referred by them to the same period. M. Marcel de Serres[1] alludes to the discovery at Monte Bolca, by Scheuchzer, of some *Neuropterous* insect of the genus *Libellula.* Scheuchzer's notice of this insect is also alluded to by Signor Massalongo,[2] who, in 1856,[3] described and figured seven fossil insects from this locality, referable to the following orders:—

		Species.			Species.
Coleoptera	... ...	2	Neuroptera	... ...	2
Orthoptera	... ...	1	Diptera	... ...	2

Although so few insects have been found in these deposits, they have been for centuries celebrated for their fossils, especially *Ichthyolites.*[4]

AMERICAN STRATA.

Recent or Post Tertiary.

In the 5th volume of the "Transactions of the American Entomological Society"[5] Dr. G. H. Horn describes certain *Coleopterous* remains discovered in cave deposits (belonging to the Post Pliocene period) at Port Kennedy, Pennsylvania. From these remains[6] Dr. Horn has identified some ten species of *Coleoptera.*

1 "Il parait que l'on trouve également des insectes fossiles dans les Marnes calcaires fluviatiles de Monté Bolca dans le Veronnais. Du moins. Scheuchzer cite-t-il des *Libellules* avec leur ailes étalées qui selon lui en provenaient." "Géognosie des Terrains Tertiaires," &c., p. 234.

2 Che io mi sappia Scheuchzer fu il primo che ci parlasse come comportavano le scienze a suoi giorni, di un insetto fossile del M. Bolca, nel suo *Herbarium Diluvianum,* dove una *Cordulia,* (?) che ebbe in dono dal suo amico Vallisnieri si trova descritta e figurata. "Studii Paleontologici," p. 12.

3 *Op. cit.,* pp. 11-21.

4 Note.—Since the date of this paper (1st June, 1877) Professor Rupert Jones, F.R.S., has informed me that a quantity of insect remains have been obtained from Serzanne (Marne), France, in fresh-water limestone of *Lower* Eocene date ; and that, when in Paris, he saw some delicate plaster casts of these insects, which had been made by Professor E. Hébert and his assistants, at the Sorbonne. Remains of plants from this formation were described by Count Saporta in 1868, but I have not been able to find any description of the insects.

5 "Trans. American Ento. Soc." Vol. v., pp. 241-245. I am indebted to Mr. R. M'Lachlan, F.R.S., for calling my attention to this paper.

6 Since this paper was read, on the 1st June last, Mr. S. H. Scudder has described two new species of *Carabidæ* found in the inter-glacial deposits of Scarborough Heights, near Toronto, Canada. One species has been named by Scudder *Loricera glacialis* and the other *Loxandrus gelidus.*—See the "Bulletin of the United States Geological and Geographical Survey," Vol. iii., No. 4. August, 1877.

TERTIARY.

The earliest discoveries of fossil insect remains from the American Tertiary formations, appear to have been made several years ago by Professor Denton,[1] in shales in Colorado, near the junction of the Green and White Rivers. They are said to have been found in two distinct localities sixty miles apart, the specimens in one place differing from those of another, not only specifically, but in their general character. Subsequent investigations in other parts of the same region have since been made by Mr. F. C. A. Richardson, and also by Dr. Hayden. In a letter to the editors of the "American Naturalist,"[2] Mr. Richardson says:—"I discovered and collected the fossil insects on the Green River in Wyoming territory, on the line of the Union Pacific Railroad, some 40 miles this side (east) Salt Lake City; or, to be more precise, the locality is five miles west of Green River City, and on the railroad track. The shale, or portion of shale, in which the insects were found runs in a circle from the N.E. to the S.W., as if on the border of a small lake. I also noticed that the fish are not in regular order, as the insects, which cover a space about two feet wide, and form a ring or belt around the lake."

On the subject of the insects discovered by Mr. Richardson, Mr. Scudder says[3]—"About 100 slabs, mostly of very small size, were brought away; these contained at least 175 specimens, including in that number all the reverses. Of these specimens, 35 cannot be referred with certainty to any subordinal group, since they consist merely of abdominal segments, or blurred and distorted fragments, the affinities of which can only be rudely surmised. The remainder are referable to nearly 40 species belonging to the following groups, mainly arranged in the order of numerical superiority:—

			Species.				Species.
Diptera	66	specimens	= 13	Hemiptera	4	specimens	= 2
Coleoptera	52	,,	= 12	Orthoptera	4	,,	= 2
Hymenoptera	5	,,	= 3	Neuroptera	2	,,	= 2

[1] See "Proceedings Boston Society of Natural History," Vol. xi., 117-118; also the "American Naturalist," Vol. vi., for Nov., 1872.

[2] See Vol. vi.

NOTE.—I have thought it advisable to refer to the American Tertiary formations, and their fossil insect remains, after concluding my observations on the European formations of this period, especially as I am unaware whether the American strata should be referred to the Pliocene, Miocene, or Eocene divisions of this period.

[3] See Mr. Scudder's paper in Vol. vi. of the "American Naturalist" for November, 1872.

"Of the *Diptera*," continues Mr. Scudder, "one half of the specimens belong to single, or possibly two heavy-bodied species of small size, which although invariably wingless, are presumed to be so only by mutilation, since exceedingly few wings are preserved on any of the stones; of the other half two-thirds are *Tipulidæ* or *Mycetophilidæ*, and include five of the species, while the remaining sixth comprises about half the species and belongs to various groups. Of the *Coleoptera* fully one-half the species, and about $\frac{7}{10}$ths of the specimens belong to the *Curculionidæ;* the others mostly to the *Staphylinidiæ* and *Carabidæ*.

"The *Hymenoptera* consist of a small ant, and a *Pteromalus* like insect, and one rather obscure form. The *Hemiptera* are represented by an insect resembling *Issus*, and another apparently belonging to the *Tingidæ*. In the *Orthoptera* there are only legs of a Locustarian, about as large as our common *Phylloptera*, and a cricket, perhaps, of the genus *Nemobius*. Two *Phryganeids* are represented by wings, one of them doubtfully located in this family."

The insects discovered by Mr. Richardson are said to be entirely different from those found by Professor Denton. Mr. Scudder observes—"Comparing the assemblages of species, we find that *Diptera* and *Coleoptera* are the prevailing forms in each; but that within these groups the types differ in a remarkable manner according to their several localities; the *Orthoptera* and *Neuroptera* of the later discovered beds are wholly wanting in the earlier; the [1]*Lepidoptera* and *Physopoda* are found only in Fossil Canon, and no traces of ants appear in Chagrin Valley, though occurring in the other two places, and also in the locality examined by Dr. Hayden."[2]

Quite recently Mr. [3]Scudder has published a description of two species of *Orthopterous* insects from the Rocky Mountain Tertiaries, one of which was found by Mr. T. L. Mead at Castello's Ranch, South Park, Colorado; and the other was found in the same

[1] This turns out to be a mistake. In a subsequent paper (August 1877), Mr. Scudder says "there are no *Lepidoptera* in the collection (nor have I yet seen any from America), the supposed Noctuid proving to be one of the *Syrphidæ*, badly preserved, and the possible slug-caterpillar a Dipterous larva."

[2] The *Coleoptera* were described by Mr. Scudder in the "Bulletin of the U.S. Geological and Geographical Survey of the Territories,' Vol. ii., No. 1, March, 1876; the remainder of the insects in this collection have been described by Mr. Scudder since the date on which this paper was read, in the "Bull. U.S. Geol. and Geogrp. Survey," Vol. iii., No. 4, August, 1877.

[3] See a paper on "Fossil Orthoptera from the Rocky Mountain Tertiaries," in the "Bulletin of the Geological and Geographical Survey of the Territories," No. 6, 2nd series (Washington, February, 1876).

:ality, by Mr. Jesse Randall. The first species Mr. Scudder has scribed as *Homœogamia ventriosus*, and the latter as *Labidura tiaria*.

Since the date of the last-mentioned paper, Mr. Scudder[1] has ıblished detailed descriptions of 31 species of *Coleoptera*, most ' which were included in those before referred to as having been und by Professor Denton and Mr. Richardson; and a few others ' which were found by Mr. Mead, or by members of the United tates Geological Survey. "In this paper," says Mr. Scudder, are made known the first fossil *Coleoptera* from the Tertiaries the United States; indeed, if we except some doubtful remains und in the red sandstone of the Connecticut Valley, the first stinctively American *Coleoptera* from any formation. Two beetles ave been figured by Heer from the Miocene of Northern[2] Greennd, and these are all that have yet been described from the New Vorld."

These valuable contributions to our knowledge of the fossil ısects of the American Tertiaries were alluded to by Professor Vestwood, in his [3]Anniversary Address to the Entomological ociety of London, on the 7th February, 1877. Mr. Scudder[4] has ery recently described several species of insects obtained by Mr. I. M. Dawson from Tertiary beds at Quesnel, British Columbia. n addition to fragmentary indeterminate remains, there are ɔme 24 species distributed among the undermentioned orders as ɔllows :—

Coleoptera	1	Hemiptera	1
Neuroptera	1	Diptera	14
Hymenoptera	7		

AMBER.

Nowhere have fossil insects been found in [5]greater numbers, or n a more beautiful state of preservation, than in "that resinous and itumenous substance known as Amber."

[1] See a paper on "Fossil Coleoptera from the Rocky Mountain Teriaries," in the "Bulletin of the Geological and Geographical Survey of the Territories," Vol. 2, No. 1 (Washington, March 21, 1876).

[2] In 1868 Dr. Oswald Heer described four insects from the Miocene of North Greenland. (See Flora Fossilis Arctica, 129-130.)

[3] See the Anniversary Address to the Entomological Society of London, on the 7th February, 1877, by Professor Westwood, M.A., F.L.S.

[4] See Report of Progress, 1875-1876—"Geological Survey of Canada."

[5] See "Traité elémentaire de Paléontologie," by F. J. Pictet. Vol. iv., p. 97.

The origin of Amber has been the subject of much controversy. Some ancient writers attributed it to Ants, and some considered it to be of mineral origin. It is now considered, by all authorities, to be of vegetable origin, and to have been formed from the resin which distilled from the trunks of certain species of *Coniferæ* of the Tertiary epoch,[1] whose fossilized remains form the beds of lignite in which it is frequently obtained.

In some cases the leaves of the *Coniferæ* have been found in Amber; and although, according to Dr. Bérendt, they appear to differ from all known species, he thought himself justified in ascribing them to the genus *Pinus*. With reference to his opinion, the Rev. F. W. Hope observes[2]—"In a letter lately received from Dr. Bérendt, he informs me that the anotomico-microscopical examination of the wood places it beyond a doubt that the Amber was a *Pinus*; but of what species cannot be now known; but that *Pinus balsamea* approaches nearest to it in appearance."

Amber is said to be occasionally thrown on the beach of the Eastern coasts of England, along with masses of jet; and if not torn from the bed of the sea, may have been washed from the Baltic, where, according to Dr. Bérendt, the geographical focus of the Amber wood was situated. Speaking of its occurrence on the Eastern Coasts of this country, Mr. Brodie[3] observes that, "although the communication between the Baltic Sea and the German Ocean is broken by the land of Denmark, and only exists through the Island of Zealand, and other islands which lie between Denmark and Sweden, it is quite possible, and by no means improbable, that currents may have conveyed pieces of Amber from the coasts of the Baltic, through the Cattegat, into the North Sea, and thence they would occasionally, though rarely, be picked up on our Eastern Coasts." They may perhaps have been brought thence during the Post Tertiary[4] period, when what is now the land of Denmark was depressed[5] beneath the ocean, and the North Sea and the Baltic formed one uninterrupted expanse of water.

[1] Pictet *op. cit.*, Vol. iv., p. 98.

[2] Rev. F. W. Hope, F.R.S., &c., on "Succinic Insects," Trans. Ent. Soc. London I., Part 3, pp. 138-147.

[3] See Brodie's paper "On the nature and origin of Amber," in the 35th Annual Report of the Warwickshire Natural History Society (April, 1871).

[4] (?) Upper Miocene Period.

[5] See the map at the end of Heer's "Recherches sur le Climat et la Végétation du pays Tertiaire."

Amber is also abundant on the shores of Sicily[1] and the Adriatic Sea; also in the beds of lignite or brown coal in Germany and Prussia, and it is occasionally found in Spain, France, Russia, Africa, and Brazil. Mr. Hope says that it has been found in the gravel pits near London; and Mr. Brodie states that he has detected small pieces of resin in the clays of the Wealden, in the Isle of Wight.

Professor Heer observes[2] that Amber is found not only on the coasts of the Baltic Sea, from Kœnigsberg to the Eastern coasts of Jutland; but also, although much more sparingly, on those of the North Sea (at Heligoland); on the Western coasts of France; in Iceland and in Greenland; then in another direction in the North of Siberia as far as Kamtschatka; it is found also in the Tertiary formations of the interior, in the grit or sandstone of Gallicia; and, according to M. K. Mayer, in the blue marls of the Pliocene formation of Castel-Arquato; it is met with also in the lignites of Lobsann, in Alsace, at Schienerberg, near Œningen, and in Sicily.

One of the richest deposits of Amber, is in that part of the province of Prussia called Samland, which is bounded on the west and north by the Baltic. In some parts of this district, according to [3]Professor Zaddach, fine sections of the Tertiary strata (at a height of from 80 to 125 feet above sea level) are exposed. The lower portion of these strata is said to consist of beds of Glauconitic sand, overlaid by the brown coal formation, from 60 to 100 feet thick. The lower portion of the Glauconite sand, says Zaddach, is cemented, by hydrated oxide of iron, into a coarse sandstone, which contains numerous fossils; below this is a deposit of finer quartz grains and more Glauconite and clay and mica; associated with the above, in descending order, is a wet sandy stratum called quicksand, succeeded by a blue earth—fine-grained and argillaceous. In this the Amber is found abundantly, but generally in small pieces. Above and below the Amber earth only a few isolated pieces of Amber occur. Mr. Brodie observes that the species of fossil shells discovered in this Amber earth, determine the age of these strata to belong to the Eocene, or oldest formation of the Tertiary period.

[1] M. Oustalet observes that Amber is found in the blue marls referable to the Pliocene period at Castel-Arquato in Sicily.

[2] "Recherches sur le Climat et la Végétation du pays Tertiaire," p. 113.

[3] See a translation of Professor Zaddach's paper in the April Number of the "Quarterly Journal of Science" for 1868.

Some portion of the Amber, found in such quantities in this province of Samland, was probably formed in the vast pine forests of the Scandinavian peninsula, and then washed down by the rivers flowing therefrom into the German continent. In order to understand this theory, it must be remembered that the Scandinavian peninsula is believed not to have been entirely separated from the German continent, during the Tertiary period, by the Baltic Sea, as at the present day; but to have been connected with the continent by a [1]neck of land, many miles in width, extending from the neighbourhood of Kœnigsberg to that of Dantzic. In no other way can we account for the fact that the Prussian Amber contains remains of the Scandinavian flora mingled with that of the Sub-Alpine type.

Professor Zaddach[2] is of opinion that the Tertiary Glauconite was derived from the green sand of the older cretaceous formation, the younger beds of which constitute a part of the Danish Island of Bornholm. He is also of opinion that the trees which yielded the Amber, must have grown upon the green sand beds of the cretaceous period, flourishing luxuriantly upon the marshy coasts which then surrounded the great continent of Northern Europe.

There appears to be the very best possible evidence that all Amber was not formed during one and the same epoch.[3] Professor Heer[4] says that the Amber of Kleinkuhren belongs to the Upper Eocene period, while some is found in strata referable to the Lower Miocene period ; and that the Amber of the lignites of Lobsaun, and that of the blue marls of Castel-Arquato (Pliocene), proves that the trees which produced it existed throughout the Tertiary epoch.

The long period throughout which the Amber-producing trees existed, and their geographical distribution, accounts for the fact that in the plants and insects discovered in Amber, the mixture of Northern and Southern forms is much more striking than in

[1] See map at the end of Heer's "Recherches sur le Climat," &c.

[2] "Quarterly Journal of Science" for April, 1868.

[3] M. Gœppert appears to have considered Amber as belonging to the Pliocene period, from his having identified no less than 30 species of plants found therein, with existing species. See "Die Bernstein-flora, Monats bericht der Berliner Academie," 1853. Dr. Heer refers the strata at Samland, from which the Amber is obtained, to the *upper section of the Upper Eocene*, and the *upper section of the Lower Miocene*. "Recherches sur le Climat," &c., p. 111-112.

[4] Op. cit p. 114.

any one European formation of the Tertiary period; and why many types are there met with belonging to high latitudes, as well as types of mountain species; *e.g.*, the insects and spiders from Amber include, says Heer, types of the tropical and subtropical zones, such as *Termites*, *Pæocera*, *Halobates*, *Polyzosteria*, *Passandra*, *Plecia*, *Sylvius*, *Hersilia*, *Chauliodes*, *&c.*, and also Northern forms, such as *Mochlonyx* and *Gloma.*

Amongst the very numerous authorities which I have consulted on the subject of Amber, and its organic remains, considerable difference of opinion appears to prevail as to the proportion of the specimens, detected in Amber, which belong to extinct genera and species; but, by far the greatest number of authorities, including Hope, Koch, Germar, Pictet, Hagen, Lœw, and Menge, appear satisfied that amongst the many thousands of insects and spiders found in Amber, all of them, with the exception of a very small number, are different from living species; though many of them are closely allied to, and may be considered as analogous with, species now living. On this subject Mr. Hope observes, "The insects at present detected in Amber appear to relate to species extra European, many of them belonging to tropical climes[1]; while some approach South American and Indian forms. They do not appear related to any existing species, and are, therefore, probably extinct, and this seems to be the opinion of Germar, Jussieu, De Jean, Dr. Leach, and others."

Professor Pictet, who has paid special attention to the remains of *Neuroptera* in Amber, is of the same opinion. Amongst the *Neuroptera* he recognises: firstly, species allied to, but not identical with, those existing in Prussia at the present day; secondly, intertropical and Mediterranean species; thirdly, exotic types; fourthly, certain extinct species without any representatives at the present day.

On the other hand,[2] Dr. Burmeister states that the families, genera and species of insects, found in Amber, present a conformity, in the majority of instances, with existing forms, and

[1] Quant aux insectes disséminés dans le Succin, on a avancé que généralement, ils ont plus de rapport aux éspèces des climats chauds, qu, à ceux des régions témpérés, et. par conséquent ils sont, pour la plupart, étrangers aux climats de la Prusse et de la Poméranie ou le succin insectifère se trouve en grande quantité, si ce n'est pas dans son véritable gîte. Marcel de Serres "Géognosie des Terrains Tertiaires." Livre iv.me. p. 238.

[2] Burmeister's "Manual of Entomology," p. 575.

even an identity of species; and that no new forms have been observed, and existing genera are readily recognised.

Professor Westwood states that in the Taylor Museum, at Oxford, are several insects, in Amber, from Catania, in Sicily; and that they are very interesting and different to those of the Baltic: he also adds that the insects figured and described by Dr. Bérendt are, many of them, very like the insects of the present time.

The remains of insects in Amber are very numerous. Swammerdamm is said to have had in his collection 166 specimens of *Coleoptera*, and Frishch more than 200. Dr. Bérendt had over 1,000 specimens, among which, however, were many duplicates.

The number of species of the different orders of insects discovered in Amber, and enumerated by Mr. Hope, in the list at the end of his paper on "Succinic Insects," is as follows:—

Of the Coleoptera[1]	about	160 species.	Of the	Orthoptera	...... about	12 sp.
„ Homoptera	„	11 „	„	Hemiptera	„	15 „
„ Neuroptera	„	10 „	„	Lepidoptera (Papilio)		10 „
„ Hymenoptera	„	25 „	„	Diptera	„	22 „

Mr. Hope also gives a list[2] of insects from Copal and Animé, which includes:—

Coleoptera	9 species.	Hemiptera	1 species.
Hymenoptera	2 „		

In his "Fauna der Vorwelt,"[3] Dr. Giebel enumerates 318 species from Amber, viz.:—

Coleoptera	106 species.	Neuroptera	28 species.
Hymenoptera	14 „	Orthoptera	4 „
Lepidoptera	3 „	Hemiptera	22 „
Diptera	141 „		

With regard to the ten species of *Lepidoptera* enumerated in the lists compiled by Mr. Hope, it may be observed that it is doubtful whether they included any butterflies, because the generic term "*Papilio*" made use of therein, was anciently applied to all *Lepidoptera*, both *Rhopalocera* and *Heterocera*.

[1] See Hope's paper on "Succinic Insects," Transactions of the Ent. Soc., Lond., Vol. i, pt. 3, 133-147. Bérendt's "Die Insekten in Bernstein." Burmeister's "Handbüch der Entom^{e}." A Monograph by Dr. Bérendt in the Memoirs of the Ent. Soc. France, t. v. p. 539, and Pictet's "Paléontologie," Vol iv, pp. 97-144.

[2] See Transactions Ent. Soc., Lond, Vol. ii, pp. 46-57.

[3] "Fauna der Vorwelt" (Insekten and Spinnen), pp. 393-426.

Mr. Scudder is of opinion that the probable nature of the ancient forest of Amber renders it unlikely that any butterflies, in their perfect state, could be found in it; he states, however, that Dr. Hagen had informed him that he had himself seen specimens of large butterflies in Amber, but that they proved to be *falsifications*, recent European insects, like *Pieris Rapæ*, having been enclosed between slabs of it, which were then fastened together, and the edges roughened, in so clever a manner that no one would have suspected them to be spurious.[1]

With this imperfect notice of Amber, and the insect remains detected therein, I must bring this paper to a conclusion.

The second paper of the series will be devoted to the Insect Fauna of the Secondary or Mesozoic Period, and the British and Foreign Strata in which their remains have been detected. In the third paper I shall describe the insect remains from the British and Foreign Strata of the Primary or Palæozoic Period, and shall conclude with some general observations as to the deductions which may be drawn from a study of Fossil Insects.

A LIST OF INSECT REMAINS DISCOVERED IN THE FORMATIONS OF THE RECENT OR POST TERTIARY PERIOD.

BRITISH STRATA.

Peat and Brick-earth, Lexden Brick Pit, Lexden, near Colchester[2]:—

Remains of *Coleoptera;* including *Cassididæ, Coccinnellidæ, Chrysomelidæ, Curculionidæ, Carabidæ* and *Buprestidæ.*

Boulder formation or drift of the Cliffs of Eastern Norfolk[3]:—

[1] Pictet observes, "Il faut aussi se défier beaucoup de contrefaçons exécutées dans divers pays dans le but d'un gain illicite." Traité de Paléontologie, Vol. iv., p. 99.

NOTE.—For further information on Insects in Amber, see Bromell's "Lithographia Suecana Acta litteraria Sueciæ," 1729.

"Historia Succinorum aliena involventium," Lipsiæ, 1742, by Sendelius.

"Géognosie des Terrains Tertiares," &c., 1829, by Marcel de Serres.

Observations on Succinic Insects, by the Rev. F. W. Hope, F.R.S., in the transactions of the Entomological Society, London, Vol. i., 1834.

"Lethea Géognostica," &c., Vol. ii., p. 811, by H. G. Bronn, 1835.

"Handbūch der Entomologie," by Dr. Burmeister.

"Die Insekten in Bernstein," by Dr. G. C. Bérendt.

"Insectes dans l'ambre," Ehrenberg.

[2] See page 290 ante.

[3] See page 291 ante.

Elytra of *Coleoptera;* including two species of *Donacia*; an *Elater ;* an elytron of one of the *Harpalidæ ;* and an elytron of *Copris Lunaris.*

FOREIGN STRATA.

Lignites of Uztnach and Dürnten, in Switzerland [1] :—

A coleopterous insect allied to *Feronia leucophthalma*, another similar to *Callidius fennicum.*

Elater æneus?	Pterostichus nigrita,
Donacia discolor?	Carabites diluvianus,
„ sericea?	„ cordicollis.
Hylobius rugosus,	

Elsinore [2] :—

Cervus longirostris,	Buprestidæ, &c.
Aphodius fossor,	

A LIST OF INSECT REMAINS DISCOVERED IN THE FORMATIONS OF THE TERTIARY PERIOD.

BRITISH STRATA.

LOWER MIOCENE.

Neighbourhood of Antrim, Ireland[3]:—Elytra of two species of *Coleoptera.*

Lignites and clays of Bovey Tracey :—*Buprestes Falconeri.*

UPPER EOCENE.

Eocene Freshwater limestone of Gurnet Bay, Isle of Wight:—

Remains of *Diptera*, including wings of *Tipulidæ* and *Culicidæ*[4]—

One wing of a *Hemipterous* insect.

1 *Homopterous* insect identified as *Triecphora sanguinolenta.*

2 Specimens of *Lepidoptera* (*Lithosia*).

3 *Orthoptera* (one a *Gryllotalpa*).

[1] "Urwelt der Schweiz" and Oustalet's "Recherches sur les Insectes fossiles, &c."

[2] Bull. Soc. Geol. France, t. ix., p. 114.

[3] See Mr. Brodie's paper on the distribution and correlation of Fossil Insects, and Mr. Judd's paper on the Volcanic Rocks of Scotland, "Geological Journal," August, 1874, Vol. xxx., No. 119, p. 274.

[4] "Nature," for December, 1874 (Vol. xi). A'Court Smith in litt: and Abstracts (No. 343) of the "Proceedings of the Geological Society of London" (Session 1877-78).

12 *Coleoptera* (including *Hydrophilus*, *Dyticus*, *Curculio*, *Anobium*, *Dorcus*, and *Staphylinus*).
35 wings of *Hymenoptera* (including *Myrmica*, *Formica*, and *Camponotus*).
23 specimens of *Neuroptera* (including *Termes*, *Perla*, *Libellula*, *Agrion*, *Phryganea* and *Hemerobius*).

Middle Eocene.

Creech Leaf beds, Corfe, Dorset:—
Elytra of *Buprestidæ*.
„ of *Helopidæ*.
„ of *Curculionidæ*.
Bournemouth Leaf beds:—
Elytra of *Coleoptera*, *Hymenoptera*, *Neuroptera*, *&c.*

Lower Eocene.

London clay near Parkhurst, Isle of Wight[1]:—Elytra of *Coleoptera*.

Paludina beds at Peckham,[2] London:—Elytra of *Coleoptera*.

FOREIGN STRATA.

The following list, compiled from "Recherches sur le Climat et la Végétation du Pays Tertiaire," (the French translation, by Dr. Gaudin, of Professor Heer's "Untersuchungen über das Klima und die Végétations Verhaltnisse des Tertiärlandes") will show the names of the orders, groups, and families of insects, obtained from the Œningen strata, from Radoboj, and from the Swiss Molasse, and the number of species comprised in each family.

Upper Miocene.

Œningen.

Coleoptera.—518 species.

		Species.			Species.
I.	[3]Geodephaga	... 54	II.	Hydradephaga	... 12
	Carabidæ	... 54		Dyticidæ	... 12

[1] Mantell's "Geology of the Isle of Wight," p. 101.

[2] "Geologist," January, 1861, pp. 39-40.

[3] In this list I have adopted the arrangement of Professor Heer and Dr. Gaudin, but I have altered the *terminations* of the names to those used by Waterhouse in his "Catalogue of British Coleoptera," or by Pascoe in his "Zoological Classification."

	Species.
II. [1](GYRINIDA)	2
Gyrinidæ	2
V. BRACHELYTRA	10
Protactidæ ?	2
Staphylinidæ	4
Oxytelidæ	2
Aleocharidæ	2
V. [2]NECROPHAGA—	
(CLAVICORNIA)	55
Scaphidiidæ	2
Silphidæ	1
Nitidulidæ	17
Peltidæ	15
Rhysodidæ	1
Byrrhidæ	5
Dermestidæ	2
Histeridæ	12
VI. PALPICORNIA	22
Hydrophilidæ	22
VII. LAMELLICORNIA	42
Geotrupidæ	2
Copridæ	14
Hybosoridæ	1
Aphodiidæ	4
Dynastidæ	1
Melitophilidæ	9
Glaphyridæ	2
Melolonthidæ	9
VIII. STERNOXI	67
Buprestidæ	40
Elateridæ	27
IX. MALACODERMI [3]	14
Lycidæ	1
Lampyridæ	1
Telephoridæ	5
Melyridæ	7
(X. TEREDYLA ?)	3
Tillidæ ?	2

	Species.
Lymexylonidæ	1
XI. HETEROMERA—	
(MELANOSOMATA)	5
Stenosidæ	1
Tenebrionidæ	3
Opatridæ	1
(XII. TRACHELIDA ?)	4
Cantharidæ	4
(XIII. STENELYTRA)	19
Helopidæ	6
Cistelidæ	9
Œdemeridæ	2
Lagriadæ	1
Anthicidæ	1
XIV. LONGICORNIA	30
Prionidæ	7
Cerambycidæ	14
Lamiidæ	8
Undetermined species	1
XV. XYLOPHAGA	2
Hylesinidæ	2
RHYNCHOPHORA	108
Bruchidæ	3
Anthribidæ	6
Attelabidæ	13
Antliarhinidæ	1
Cycladæ	1
CURCULIONIDÆ	
Brachyceridæ	
Brachyderidæ	
Cleonidæ	
Molytidæ	
Pristorhynchidæ	
Erirhinidæ	
Cryptorhynchidæ	
Calandridæ	
Cossonidæ	
Undetermined species	

[1] Where the name of a group standing by itself, and not as a second is in brackets, such a group is not recognised in any system of classifi adopted in this country; and it is retained merely to show the division groups, and the arrangement of the families in the work above menti

[2] Where two names are given to a group, the upper one is that gene use in this country, and the second name, in brackets, is the equivalen name used by Gaudin in the work above mentioned.

[3] I prefer *Malacodermata*, but Waterhouse and Pascoe make i *codermi.*

	Species.		Species.
Eupoda — (Chrysomelina)	... 50	Eumolpidæ	... 1
Donaciadæ	... 2	Chrysomelidæ	... 15
Hispidæ	... 4	Galerucidæ	... 9
Cassidiidæ	... 8	Undetermined species	... 8
Crioceridæ	... 1	XVII. Pseudotrimera—(Coccinellida)	... 19
Clythridæ	... 2	Coccinellidæ	... 19

Orthoptera.—20 Species.

	Species.		Species.
Euplexoptera—		IV. Saltatoria	... 12
(Dermaptera)	... 3	Locustidæ	... 3
Forficulidæ	... 3	Acridiidæ	... 7
Cursoria	... 2	Gryllidæ	... 2
Blattidæ	... 2	V. Thysanoptera	... 2
Gressoria—			
(Raptoria)	... 1		
Mantidæ	... 1		

Neuroptera.—27 Species.

	Species.		Species.
Corrodentia	... 4	Libellulidæ	... 20
Termitidæ	... 4	III. Trich ptera	... 2
I. Subulicornia	... 21	Phryganeidæ	... 2
Ephemeridæ	... 1		

Hymenoptera.—80 Species.

	Species.		Species.
I. Mellifera		III. Pupivora	
(Antophila)	... 14	(Entomophaga)	... 13
Apidæ	... 14	Ichneumonidæ	... 12
II. Prædonia	... 50	Chalcididæ	... 1
Vespidæ	... 1	IV. Terebrantia	
Formicidæ	... 44	(Phytophaga)	... 3
Scolidæ ?	... 1	Tenthredinidæ	... 3
Sphegidæ ?	... 4		

Lepidoptera.—3 Species.

	Species.
Nocturni ...	... 3
Bombycidæ ...	... 3

Diptera.—63 Species.

	Species.		Species
I. Tipularia	... 51	III. Tanystomata	... 4
Chironomidæ	... 5	Asilidæ	... 3
Gallicolæ	... 1	Tabanidæ	... 1
Tipulidæ	... 2	IV. Brachycera	... 2
Mycetophilidæ	... 15	Syrphidæ	... 2
Floralidæ ?	... 28	(V. Athericera)	... 4
II. Notacantha	... 2	Muscidæ	... 4
Xylophagidæ	... 2		

HEMIPTERA.—133 Species.

	Species.		Species.
I. HETEROPTERA		(II. HYDROCORÆ)	6
(GEOCORÆ)	108	Nepidæ	5
Scutelleridæ	6	Notonectidæ	1
Pentatomidæ	39	III. CICADINÆ	15
Coreidæ	13	Stridulantiæ	1
Lygæidæ	23	Fulgoridæ	1
Capsidæ	2	Membracidæ	1
Tingidæ	2	Cicadellinæ	12
Reduviidæ	17	IV. PHYTOPHTHIRIA	
Hydrometridæ	1	Aphidæ	3

Total number of species of all Orders from the Œningen Strata—844.

NOTE.—I am indebted to Mr. C. O. Waterhouse, of the British Museum, for suggesting certain alterations in some of the names used in the above list.

MIDDLE MIOCENE.

Radoboj.

COLEOPTERA.—42 Species.

	Species.		Species.
I. GEODEPHAGA	5	VII. MALACODERMI	4
Carabidæ	5	Telephoridæ	3
II. HYDRADEPHAGA	1	Melyridæ	1
Dyticidæ	1	(VIII. TRACHELIDA ?)	1
III. BRACHELYTRA	4	Cantharidæ	1
Omalidæ	1	IX. LONGICORNIA	3
Staphylinidæ	2	Cerambycidæ	1
Oxytelidæ	1	Lamiidæ	2
IV. NECROPHAGA—(CLAVICORNIA)	10	X. RHYNCHOPHORA	2
Silphidæ	1	Brenthidæ	1
Nitidulidæ	6	Undetermined species	1
Peltidæ	3	XI. EUPODA — (CHRYSOMELINÆ)	5
V. PALPICORNIA	1	Eumolpidæ	1
Hydrophilidæ	1	Chrysomelidæ	3
VI. STERNOXI	4	Gallerucidæ	1
Buprestidæ	3	XII. PSEUDOTRIMERA—(COCCINELLIDA)	2
Elateridæ	1		

ORTHOPTERA.—13 Species.

	Species.		Species.
I. EUPLEXOPTERA (Dermaptera)	1	III. SALTATORIA	11
Forficulidæ	1	Locustidæ	3
II. GRESSORIA (Raptoria)	1	Acridiidæ	8
Mantidæ	1		

NEUROPTERA.—19 Species.

		Species.			Species.
	CORRODENTIA	... 10	III.	TRICHOPTERA	... 1
	Termitidæ	... 10		Megalopteræ	... 1
'.	SUBULICORNIA	... 8			
	Libellulidæ	... 8			

HYMENOPTERA.—85 Species.

		Species.			Species.
	MELLIFERA		III.	PUPIVORA	
	(ANTOPHILA)	... 3		(ENTOMOPHAGA)	... 22
	Apidæ	... 3		Ichneumonidæ	... 22
.	PRÆDONIA	... 59	IV.	TEREBRANTIA	
	Vespidæ	... 1		(PHYTOPHAGA)	... 1
	Formicidæ	... 57		Uroceridæ ?	... 1
	Sphegidæ	... 1			

LEPIDOPTERA.—8 Species.

		Species.			Species.
.	DIURNI	... 3	II.	NOCTURNI	... 5
	[1] Nymphalidæ	... 2		Noctuidæ	... 2
	[2] Pieridæ	... 1		Geometridæ	
				(Phalænidæ)	... 2
				Pyralidæ	... 1

DIPTERA.—Species 83.

		Species.			Species.
.	TIPULARIA	... 56	III.	TANYSTONIA	... 4
	Chironomidæ	... 1		Asilidæ	... 3
	Tipulidæ	... 14		Anthracidæ	... 1
	Mycetophilidæ	... 13	IV.	BRACHYCERA	... 9
	Floralidæ ?	... 28		Syrphidæ	... 9
I.	NOTOCANTHA	... 1	(V.	ATHERICERA)	... 12
	Xylophagidæ	... 1		Muscidæ	... 12

HEMIPTERA.—61 Species.

		Species.			Species.
.	HETEROPTERA		II.	CICADINÆ	... 23
	(GEOCORÆ)	... 33		Stridulantiæ	... 3
	Pentatomidæ	... 13		Fulgoridæ	... 1
	Coreidæ	... 5		Cicadellinæ	... 19
	Lygæidæ	... 9	III.	PHYTOPHTHIRIA	... 5
	Tingidæ	... 2		Aphidæ	... 5
	Reduviidæ	... 4			

Total number of species of all Orders from the Radoboj Strata—312.

'n the "Nova Acta" of the Academy of Leopold Charles, of

[1] Eugonia Atava. Mylothrites Pluto.
[2] Pontia Freyeri.

Austria, for 1839, vol. xix., Professor Unger describes eight species from this locality (Radoboj), viz :—

Rhipidia extincta.	Bibio lignarius.
„ major.	„ giganteus.
Bibio Murchisonis.	„ enterodeles.
„ gracilis.	Leptogaster Hellii.

In the "Nova Acta," &c., for 1843 (vol. xx.), Von Charpentier describes seven species from the same locality, viz. :—

Œdipoda melanosticta.	Sphinx atavus.
Myrmeleon brevipenne.	Hylotoma cineracea.
„ reticulatum.	Termes pristinus.
Libellula platyptra.	

Lower Miocene.

Swiss Molasse.

Coleoptera.—26 Species.

	Species.		Species.
Carabidæ ...	6	Elateridæ ...	2
Dyticidæ ...	1	Helopidæ ...	2
Peltidœ ...	1	Lamiidæ ...	1
Hydrophilidæ ...	4	Chrysomelidæ ...	3
Melolonthidæ ...	1	Undetermined species ...	2
Buprestidæ ...	3		

Neuroptera.—2 Species.

	Species.		Species.
Libellulidæ ...	1	Phryganeidæ ...	1

Hymenoptera.—1 Species.

Vespidæ 1

Diptera.—1 Species.

Tipulidæ 1

Hemiptera.—3 Species.

	Species.		Species.
Pentatomidæ ...	2	Cicadellinæ ...	1

Total number of species from the Swiss Molasse :—33.

List of Fossil Insects from the Brown Coal of Rott, in Siebengeberge, enumerated by Professor Germar in the "Fauna Insectorum Europæ," 19, 1837 ("Insectorum Protogææ specimen," &c.), and by Dr. Giebel in "der Zeitschrift fur die gesammte Naturwissens

haft" (viii., 1856, s. 184), and in his "Fauna der Vorwelt" 1856).

COLEOPTERA.

[1]Platycerus sepultus.
Geotrupes vetustus.
„ proavus.
Trogosita tenebrioides.
„ emortua.
Silpha stratuum.
Escheria protogaea.
Dytiscus (larva).
Buprestis major.
Buprestis alutacea.
Chrysobothris xylographica.
Dicerca carbonum.
Tenebrio effossus.
Spondylis tertiaria.
Prionus umbrinus.
Molorchus antiquus.
Saperda lata.
Bruchus bituminosus.

HYMENOPTERA.

Formica lignitum.
Osmia dubia.

LEPIDOPTERA.

Ypsolophus insignis.

DIPTERA.

Helophilus primarius.
Anthracida xylotoma.
Bibio xylophilus.
Bibio lignarius
„ dubius.

ORTHOPTERA.

Decticus extinctus.

HEMIPTERA.

Alydus pristinus.
Belostomum Goldfussi.

Further list of insects from the Brown Coal of Rott, described y C. Von Heyden, in Meyer and Dunker's "Palæontographica," 359-1861, vol. 8, pp. 1-15.

COLEOPTERA.

Hydrophilus fraternus.
Hydrous miserandus.
Byrrhus lucae.
Buprestis tradita.
Ancylochira redempta.
Dicerca Bronni.
Silicernius spectabilis.
Ptinus antiquus.
Tenebrio ? senex.
Caryoborus ruinosus.
Tophoderes depontanus.
Hylotrupes senex.

HEMIPTERA.

Notonecta primæva.

HYMENOPTERA.

Bombus antiquus.
formica ?

[1] The names given in this, and all the following lists, are in every case hose used by the authors of the works from which the lists have been comiled, and no attempt has been made to correct any but clerical errors.

LEPIDOPTERA.

[1] Vanessa vetula.

DIPTERA.

Chironomus antiquus.
Ctenophora Decheni.
Bibio deletus.
Bibio lignarius.
Bibiopsis volgeri.

Further list of insects from the Brown Coal of Rott, described by Dr. Hagen, in Meyer and Dunker's "Palæontographica," Vol. x (1863).

Calotermes rhenanus.
Leuctra antiqua.
Libellula cellulosa.
Ictinus fur.
Libellula ceres (nymphe).
Libellula cassandra (nymphe).
Aeschna Dido.
Agrion Thaia.
„ Mysis.
„ Icarus.

Further list of *Diptera* from the Brown Coal of Rott, described by Carl von Heyden and Lucas von Heyden, in Meyer and Dunker's "Palæontographica," Vol. xiv (1865-6).

Bibio pannosus.
Protomyia abava.
„ collossea.
„ Winnertzi.
„ grossa.
„ luctuosa.
„ Proserpina.
„ macrocephala.
„ hypogaea.
„ expositìtia.
„ stygia.
„ pinguis.
Protomyia veterana.
„ lapidaria.
„ grandaeva.
„ antenata.
„ lutcola.
„ schineri.
„ elongata.
„ gracilenta.
„ Heeri
Plecia rhenana.
„ heroica.

Further list of *Diptera* from the Brown Coal of Rott, described by Lucas von Heyden in Dunker's "Palæontographica," Vol. xvii, pp. 237-272 (1867-1870).

Simula pasithea.
Sciara janassa.
„ defossa.
„ atavina.
„ Rottensis.
„ Winnertzii.
Cordyla vetusta.
„ subaptera.
„ antiqua.
„ reunda.
Cordyla limnoria.
Boletina philyra.
Chironomus bituminosus.
„ perditus.
„ dorminans.
„ decrepitus.
„ Palaemon.
Ceratopogon Alpheus.
Culex ceyx.
Erioptera Danaë.

[1] This is the only butterfly yet discovered in any formation of this period.

bia sturi.
us Krantzii.
anus.
nimas.
?

Empis melia.
Pipiza venilia.
Syrphus euphemus.
Anthomyia Heymanni.
Dipterous larva of Stratiomys. ?

Coleoptera from the Brown Coal of Siebengeberge, de-
' Carl von Heyden and Lucas von Heyden, in Meyer
er's " Palæontographica, Vol. xv (1866).

us abolitus.
ıs Cretzschmari.
ius excitatus.
reductus.
ıs Neptunus.
rus morticinus.
bius Plutonis.
porus sepultus.
thus bituminosus.
demersus.
scribai.
rus Vulcanus.
phagus Giebeli.
linus (larva).
lus scaphioides.
ıs exanimatus,
ius Krantzi.
ıla tumulata.
primigenia.
thetis.
lon Bellerophon.
orus carbonarius.
exauctaratus.
caducus.
Brodiei.
primordialis.
nites tinubicola.
rantzi.
ephalum pristinum.
soum veteratum.

Bolitophagus vetustus.
Platydema Geinitzi.
Myodites Meyeri.
Mylabris deflorata.
Choragus tertiarius.
Rhynchites Hageni.
" orcinus.
Apion primordiale.
Brachymycterus curculionoid.
Sitones venustulus.
Hylobius antiquus.
Eurychirus induratus.
Larinus Bronni.
Rhinocyllus improlus.
Magdalinus protogenius.
" Deucalionis.
Tychius mauderstjernai.
Acalles Icarus.
Ceutornynchus funeratus.
Nanophyes japetus.
Sphenophorus proluviosus.
Lamia petrificata.
Labidostomis Pyrrha.
Lina sociata.
Plagiodera novata.
Coccinella Haagi.
" Krantzi.
" bituminosa.
" fossilis.
Lasia primitiva.

f insects from the Brown Coal of Sieblos, described by
Heyden, in Meyer and Dunker's " Palæontographica, Vol.
5-120 (1858).

stis Meyeri.
senecta.
us decrepitus.
es Hassencampi.

Pissodes effossus.
Leptoscelis humata.
Lygæus fossitius.
Bracon macrostigma.

Further list of insects from Sieblos, described by Carl von Heyden, in Meyer and Dunker's "Palæontographica," vol. 8, pp. 15-17 (1859).

Trachyderes bustiraptus.
Lygæus deprehensus.
Pachymerus antiquus.

In Meyer and Dunker's "Palæontographica," Vol. v. (1858), Dr. Hagen describes from the Brown Coal of Sieblos, two Neuroptera, viz.:—

Heterophlebia jucunda.
Lestes vicina.

List of insects from the Brown Coal of Salzhausen, described by Carl von Heyden, in Meyer and Dunker's "Palæontographica," Vol. iv (1856).

Dicerca Taschei.
Therera carbonum.
Bibio antiquus.

Further list of insects from the Brown Coal of Salzhausen, described by C. von Heyden and Lucas von Heyden, in Meyer and Dunker's "Palæontographica," Vol. xiv, 65-66. Taf ix, fig. 13 22:—

Lebia amissa.
Attagenus extinctus.
Anthaxia carbonaria.
„ deleta.
„ primæva
Sphenoptera knopi.
Helops wetteravicus.
Lema tumulata.
Clythra carbonaria.
Pentatomia Bottgeri
Bibiopsis carbonum
Cynips pteromalus.

List of insects from the Brown Coal of the Nether Rhine and the Rhone, compiled from Meyer and Dunker's "Palæontographica," Vol. x (1861-1863):—

COLEOPTERA.

Peltis costulata.
Onitis magus
Anoplognathus rhenanus.
Perotis Hausmanni.
„ redita.
Dicerca Taschei.
Ancylochira pristina.
Agrilus Baueri.
Limonius optalibis (Heer).
Luciola extincta.
Uloma avia.
Urodon priscus.
Cryptorhynchus renudus.
Dorcadion emeritum.
Oberea præmortua.
Hesthesis immortua.
Lina Wetteravica.
„ populeti (Heer).
Cassida interemta.
Coccinella antiqua.

ORTHOPTERA.

Blatta pauperata.

HYMENOPTERA.

Osmia carbonum.
Anthophora effossa.
Apis domitans.

NEUROPTERA.

Corydalis?

LEPIDOPTERA.

Nepticula fossilis.

DIPTERA.

Bibio tertiarius.
Merodon Germari.
Culicites tertiarius.
Cecidomyia? dubia.
Fungicola.

List of insects from the Brown Coal of Stöschen:—

NEUROPTERA.

Ascalaphus proavus (Hagen).

HEMIPTERA.

Corrixa pullus (Heyden).
„ ? Micropus „
Typhlocyba carbonaria (Heyden).

List of insects from Corent, Menat, and St. Gerand le Puy, Auvergne, Central France, compiled from M. Oustalet's "Recherches sur les Insectes Fossiles," (pt. 1):—

COLEOPTERA.

Eunectes antiquus.
Laccobius priscus.
Brachycerus Lecoquii.
Cleonus Arvernensis.
„ Fouilhouxii.
Hylobius deletus.
Anisorhynchus effossus.
Plinthus redivivus.
Bagous atavus.
Curculionites ovatus.

ORTHOPTERA.

One specimen not named.

NEUROPTERA.

Libellula minuscula.
Ascalaphus Edwardsii.
Phryganea Corentiana.
„ Gerandiana.

HYMENOPTERA.

Anthophorytes Gaudryi.

DIPTERA.

Penthetria Vaillantii.
Plecia major.
„ nigrescens.
„ pallida.
Bibio gigas.
„ Ungeri.
„ Ungeri (var marginatus).
Bibio macer.
„ alacris.
„ robustus.
„ Edwardsii.
„ cylindratus.
„ gracilis.
„ obsoletus.

Bibio Lartetii.
Protomyia longa.
" longipennis.
" inflata.
" lugens.
" Joannis.
" fusca
" Sauvagei.
Protomyia adusta.
" globularis.
" Blanchardi.
" rubescens.
" formicoides.
" incerta.
" Oustaleti.[1]
Stratiomys Heberti.

LEPIDOPTERA.

Noctuites incertissima.

UPPER EOCENE.

List of Genera of Fossil Insects from the Tertiary formations of Aix, in Provence (compiled from Mr. Curtis's paper in the "Edinburgh New Philosophical Journal" for 1829):—

COLEOPTERA.

Harpalus.
Hydrobius.
Lathrobium. ?
Ptinus. ?
Cetonia.
Sitona.
Notaris. ?
Liparus.
Hypera.
Cassida.
Chrysomela.

HYMENOPTERA.

Tenthredo.
Ichneumon.
Formica.

LEPIDOPTERA.

Phalena? or one of the Noctuidæ. ?

HOMOPTERA.

Aphis.
Tettigonia.
Asirica? or possibly Delphax.
Cixias, or Cercopis.

HEMIPTERA.

Miris.
Lygæus.
Corizus.
Cydnus.
Pentatoma. ?

DIPTERA.

Limnobia.
Gnoriste. ?
Mycetophila. ?
Bibio.
Empis.
etc.

List of genera of fossil Insects from Aix, in Provence, com-

[1] This species, *P. Oustaleti*, is not included in M. Oustalet's list. It is described by M. C. Brongniart in the "Bulletin de la Société Géologique de France," t. 4, 1876.

. Bronn's "Lethæa Geognostica," and the Rev. F. W. per in the 4th vol. of the Transactions of the "Entomo-ciety," London, pp. 250-255 :—

COLEOPTERA.

us.	Sitona.
a.	Lixus.
s.	Cleonis.
œtes.	Balaninus.
)ius.	Cionus.
linus.	Brachycerus.
bium.	Rhynchænus.
us.	Meleus.
)us.	Hypera.
pes.	Naupactus.
ntha.	Rhinobatus.
ι.	Dorytomus.
tis.	Apate.
	Scolytus.
	Hylurgus.
	Bostrichus.
m.	Trogosita.
m.	Ips.
	Callidium.
s.	Cassida.
	Chrysomela.
hites.	Coccinella.

ORTHOPTERA.

la.	Acheta.
s.	Locustæ.
alpa.	Tridactylus.

HYMENOPTERA.

edo.	Ophion.
.	Polistes.
mon.	Vespa.
s.	Formica.
s.	Chalcididæ.
lon.	

NEUROPTERA.

la.	Phryganea.
.	

HEMIPTERA.

oma.	Miris.
.	Syrtis.
s.	Nepa.

Ranatra.
Cicada.
Delphax.
Cercopis.
Tingis.
Aradus.
Corizus.
Reduvius.
Ploiaria.
Gerris.
Notonecta.
Tettigonia.
Thrips.
Aphis.

LEPIDOPTERA.

Satyrus.
Zygæna.
Sesia.
Bombyx.

DIPTERA.

Mycetophila.
Rhingia.
Bibio.
Hirtæa.
Tabanus.
Sargus.
Ceratopogon.
Nephrotoma.
Limnobia.
Corethra.
Trichocera.
Platyura.
Sciara.
Scatops.
Penthetria.
Dilophus.
Anisopus.
Asilus.
Empis.
Nemestrina.
Xylophagus.
Oxycera.
Nemotelus.
Aphritis.
Tipula.

List of Fossil Coleoptera from Aix, compiled from M. Oustalet's "Recherches sur les Insectes Fossiles des Terrains Tertiaires de la France," 2nd part:—

CARABIDÆ.

Nebria Tisiphone.
Calosoma Agassiz.
Panagæus Dryadum.
Bembidium infernum.
Bembidium Saportanum.
Feronia minax.
Feronia provincialis.
Harpalus Nero.
„ deletus.
Stomis elegans.
Polystichus Hopei.

HYDROPHILIDÆ.

Hydrophilus antiquus.
Hydrophilopsis incerta.
Hydrobius obsoletus.
Lacoobius vetustus.

STAPHYLINIDÆ.

Stenus prodromus.
„ Gypsi.
Achenium ingens.
Erinnys elongata.
„ deleta.
Lithocaris varicolor.
Xantholinus Westwoodianus.
Staphylinus calvus.
„ Germarii.
„ provincialis.
Staphylinus aquisextanus.
„ atavus.

Staphylinus prodromus.
„ priscus.
Philonthus Bojeri.
„ Marcelli.
Quedius Reynesii.
„ Lortetii.
Hygronoma deleta.

SCYDMÆNIDÆ.

Scydmænus Heerii.

LATRIDIIDÆ.

Corticaria melanophthalma.

MYCETOPHAGIDÆ.

Triphyllus Heerii.

SCARABIDÆ.

Onthophagus luteus.
Geotrupes atavus.

EUCNEMIDÆ.

One species unnamed.

ANTHICIDÆ.

Anthichus melancholicus.

CURCULIONIDÆ.

Hipporhinus Heerii.
„ Schaumii.
„ Reynesii.
Brachyderes longipes.
„ aquisextanus.
Sitones margarum.
Cleonus leucosiæ.
„ Marcelli.
„ asperulus.
„ inflexus.
„ sexsulcatus.
„ pygmæus.
Tanysphyrus deletus.
Hylobius morosus.
„ carbo.
Hylobius Solieri.
Plinthus Heerii.
Phytonomus firmus.
„ annosus.
Coniatus minusculus.
Erirhinus Chantrei.
Hydronomus nasutus.
Balaninus Barthelemyi.
Sybines melancholicus.
Cryptorhynchus gypsi.
Cæliodes primigenius.
Cossonus Marionii.
Curculionites parvulus.
„ lividus.
„ exiguus.

SCOLYTIDÆ.

Hylesinus facilis.

CERAMBYCIDÆ.

Clytus leporinus.

CHRYSOMELIDÆ.

Crioceris margarum.
Chrysomela Lyelliana.
„ matrona.
„ Matheroni.
Chrysomela debilis.
Gonioctena Curtisii.
Cassida Blancheti.

List of Fossil Lepidoptera (Rhopalocera) from Aix, compiled from Scudder's "Fossil Butterflies," in the Memoirs of the American Association for the Advancement of Science :—

Neorinopis sepulta.	Thaites ruminiana.
Lethites Reynesii.	Pamphilites abdita.
Coliates Proserpina.	

MIDDLE EOCENE.

List of species from Monte Bolca, near Verona, in Italy, compiled from Massalongo's "Studii Paleontologici" :—

COLEOPTERA.

Ancylochira deleta.	Perotis lævigata.

ORTHOPTERA.

Forficula Bolcensis.

NEUROPTERA.

Cordulia Scheuchzeri.	Termes peccanae

DIPTERA.

Dipterites Angelinii.	Bibio Sereri.

AMERICAN STRATA.

RECENT OR POST TERTIARY.

[1] List of Fossil Coleoptera from Cave deposits (belonging to the Post Pliocene period), at Port Kennedy, Pennsylvania, described by Dr. G. H. Horn in the "Transactions of the American Entomological Society," Vol. v., pp. 241-245 (Sept., 1876) :—

COLEOPTERA.

Cychrus Wheatleyi.	Dicaelus abutaceus.
Pterostichus (2 species not named)	Choridium (?) ebuinum.
Cymnidis aurora.	Phanæus antiquus.
Chlænius punctulatus.	Aphodius precursor.

Carabidæ discovered in the Interglacial Deposits of Scarborough Heights, near Toronto, Canada (described by Mr. S. H. Scudder, in the "Bulletin of the United States Geological and Geographical Survey" (Vol. iii., No. 4, art. xxx.) :—

Loricera glacialis.	Loxandrus gelidus.

[1] I have not myself seen the volume of the Transactions of the American Entomological Society, in which these species are described, but am indebted to Mr. R. M'Lachlan, F.R.S., for an extract from it, and for the list of species here given.

TERTIARY.

List of some of the Fossil Insects, from the Rocky Mountain Tertiaries, (Tertiary Beds of White River), obtained by Professor William Denton, and described by S. H. Scudder. (Compiled from the "Bulletin of the Geological and Geographical Survey of the Territories," Vol. ii., No. 1):—

COLEOPTERA.

Bembidium exoletum.	Spermophagus vivificatus.
Laccophilus ?	Bruchus anilis.
Philhydrus primævus.	Oryctoscirtetes protogœum.
Staphylinites obsoletum.	Trypodendron impressus.
Gyrophæna saxicola.	Sitones grandœvus.
Leistotrophus patriarchicus.	Otiorhynchus perditus.
Lathrobium abscessum.	Entimus primordialis.
Oxytelus pristinus.	Eudiagogus saxatilis.
Antherophagus priscus.	,, examinis.
Phenolia incapax.	,, effossus.
Chrysobothris Haydeni.	Hylobius provectus.
Epiphanis deletus.	Anthonomus defossus.
Corymbites velatus.	Cryptorhynchus annosus.
Oxygonus mortuus.	Eurhinus occultus.
Chauliognathus pristinus.	Brachytarsus pristinus.
Sitodrepa defuncta.	

ORTHOPTERA.

Homœogamia ventriosus.	Labidura Tertiaria.

List of the remainder of the Insects obtained by Professor William Denton, in Tertiary Beds of White River, and described by Mr. S. H. Scudder, in the "Bulletin of the United States Geological and Geographical Survey" (Vol. iii., No. 4, Art. xxix.):—

HYMENOPTERA.

Formicidæ.

Camponotus vetus.	Liometopum pingue.

Ichneumonidæ

Ichneumon petrinus.

DIPTERA.

Culicidæ.

Culex proavitus.	Corethra exita.

Chironomidæ.

Chironomus depletus.	Chironomus patens.

Cecidomyidæ.

Lasioptera recessa.	Lithomyza condita.

Tipulidæ.

Dicranomyia stigmosa.
„ primitiva.
„ rostrata.
Spiladomyia simplex.
Pronophlebia rediviva.
Cyttaromyia fenestrata.
Tipula decrepita.
„ tecta.

Mycetophilidæ.

Mycetophila occultata.
Sackenia arcuata.
Gnoriste dentoni.

Cyrtidæ.

Acrocera hirsuta.

Syrphidæ.

Eristalis lapideus.

Muscidæ.

Musca ascarides.
„ bibosa.
Musca hydropica.
„ vinculata.

Helomyzidæ.

Heteromyza detecta.

[1] COLEOPTERA.

Carabidæ.

Bembidium exoletum.

Dyticidæ.

Laccophilus (allied to L. Maculosus).

Staphylindæ.

Gyrophœna saxicola.
Leistotrophus patriarchicus.
Oxytelus pristinus.

Elateridæ.

Epiphanis deletus.
Oxygonus mortuus.

Bruchidæ.

Bruchus anilis.

Curculionidæ.

Entimus primordialis.

HEMIPTERA.

Fulgoridæ.

Aphana atava.
Delphax senilis.

Tettigonidæ.

Tettigonia obtecta.
Bythoscopus lapidescens.

Lygæidæ.

Pachymerus petrensis.

Physopoda.

Melanothrips extincta.
Lithadothrips vetusta.
Palœothrips fossilis.

NEUROPTERA.

Phryganidæ.

Phryganea operta.

[1] These *Coleoptera* were included in the preceding list.

List of Fossil Insects obtained by Mr. George M. Dawson, from ıe Tertiary Beds at Quesnel, British Columbia, and described by Ir. S. H. Scudder. (Compiled from the "Report of Progress," 875-1876—Geological Survey of Canada) :—

COLEOPTERA.

Nitidulidæ.

Prometopia depilis.

NEUROPTERA.

Odonata.

One species allied to Diplax minuscula.

HYMENOPTERA.

Formicidæ.

Formica arcana.
Aphœnogaster longœva.
Hypoclinia obliterata.

Ichneumonidæ.

Pimpla saxea.
Pimpla decessa.
Pimpla senecta.

Braconidæ.

Calyptites antediluvianum.

DIPTERA.

Chironomidæ.

Several species referable to this family.

Mycetophylidæ.

Boletina sepulta
Brachypeza procera.
Brachypeza abita.
Trichonta Dawsoni.

Dolichopodidæ.

A single specimen referable to this family not named.

Anthomyidæ.

Anthomyia inanimata.
Anthomyia Burgessi.

Helomyzidæ.

Heteromyza senilis.

Sciomyzidæ.

Sciomyza revelata.

Ortalidæ.

Lithortalis picta.

Lonchaeidæ.

Lonchæa senescens.
Palloptera morticina.

HEMIPTERA.

Aphidæ.

Lachnus petrorum.

On the Flints of the Chalk of Yorkshire.

By R. Mortimer, Esq.

Part I.

(Read May 4th, 1877.)

In this paper I purpose to show the true distribution of flint in the Chalk of Yorkshire, and to make a few observations of geological interest. A glance at the map will show that the Chalk hills or Wolds of Yorkshire present a crescent-shaped appearance. Their outer margin stands boldly 300 and 600 feet above the Vale of Pickering on the north, and somewhat higher, and equally abrupt, over the plain of York, on the west. The highest point of elevation is found close to Garrowby Hill top, at a height of 808 feet above the sea level.

The beds exhibit numerous local displacements, some of a very violent nature, but the general dip of the whole mass (except a narrow strip on its northern edge, which inclines slightly to the north) appears to be towards a central point in Holderness, in the vicinity of Dunnington and Hornsea. The dip is greatest towards the south and south-east. At the north landing, Flamborough, the dip is from 12 to 14 degrees to south south-east. Southwards from that point it is much less. The northern edge of the Wolds appears to have been partially eaten away and straightened by marine denudation, as shown by reference to the map. With this trifling exception, there is no evidence whatever now existing of Chalk having extended further north in England. The present form of the Wolds seems to suggest that they are an accumulation by animal secretion, after the manner of an Atol or circular reef, probably one of a chain, rather than the fragment of a vast sheet of Cretaceous mud deposited in deep water.

The Chalk area may be divided into two distinct portions—

A. Flint-bearing.

B. Non-Flint-bearing.

On the accompanying map, with which I shall illustrate my remarks, the portion covered by lines and small circles denotes the surface area of the Chalk with flints; the portion free from lines denotes the surface area of the Chalk without flints; whilst the narrow zone, shown by broken lines, denotes the area of the gradual blending and dove-tailing of the two kinds of chalk.

Flint-bearing.—The flint-bearing portion has an average breadth


Supposed line of denudation
FILEY BAY
Flamboro Head
Bridlington
Weaverthorpe
North
Aldro
Fimber
Driffield
YORKSHIRE WOLDS
HOLDERNESS
Hornsea
Market Weighton
Beverley
Hull
Hessle
Drift with flinty chalk beneath
Drift with flintless chalk beneath
Chalk without flints
Intermediate Stage
Chalk with flints
Speeton Clays

of about six miles, except between Flamborough and Filey, where it has been eaten away by the action of the tides, and is only about one mile in width. Its greatest ascertained thickness is about 400 feet, and in the main it lies conformably on beds of grey and marly chalk. These basement beds vary in colour from a dirty grey to a dirty yellow, with lines of nodular secretions in places, and at the base runs into the Red Chalk. They contain no flint, and are found to range from 20 to 80 feet in thickness.

For a full knowledge of the existence of flint throughout the area marked by circles on the map, I am indebted to many kind correspondents and to many personal visits. The most southern point of the flint-bearing beds on the coast is at Silex Bay, opposite the Light-house at Flamborough. Here, at first, flint is very sparingly distributed in small detached nodules, but after passing northwards for about three-quarters of a mile, these increase in size and number, and gradually become associated with nearly horizontal lines and tabular beds, which extend unbroken for considerable distances. These tabular beds increase in importance northwards, and before reaching the north landing at Flamborough are abundant, and in places attain a thickness of six to eight inches. Protruding from one to two feet above the clean-washed Chalk beds, which at most times form the beach at the north landing, are several stump-like portions of large columns of flint, with an admixture of chalk, measuring from 2 to 5½ feet in diameter. These for the most part have a dish-shaped cavity in the centre from 1 to 2 feet in diameter, filled with hard chalk.

On the south side of the landing, low down in the face of the cliff, and in a line with those protruding from the beach, is a specimen almost entire and standing erect. It measures 6½ feet in height and 3½ in diameter. At the top there is exposed for a distance of ten inches on one side a centre core of chalk or chalky flints, 12 inches in diameter, and slightly fluted horizontally. On each side of this specimen, as of all the others, which I have closely observed, there is a bending downwards of the adjacent beds of Chalk, the compression disappearing immediately above and below the specimens. This local dip or bending extends from 4 to 8 feet all round, according to the size of the specimen, and is a very puzzling feature. A little way further round to the south, high up in the cliff, a similar specimen lies apparently on its side, with one end slightly protruding. This specimen seems to have been uprooted previous to its entombment, as quite near are others in a standing position. North-

wards from this point to Speeton, I observed, during a visit last autumn, in the cliff and on the beach, not fewer than thirty specimens, whole or in fragments. A portion of one of these, 8 stones in weight, my man and I (after exploring till a late hour among the huge blocks of chalk thickly scattered on the shore) jointly carried up the steep and rugged ascent of the cliff to the Speeton Station. This specimen gives a fine horizontal section, and shows numerous zones of flint, alternating with zones of chalk. From Flamborough to Speeton, flint is present in the cliff everywhere, and in all forms.

A similar specimen to these huge Flamborough aggregations I remember observing ten years ago, in a pit at the Painsthorpe Wold, near the N.W. margin of the Chalk. And in a short memorandum made at the time, I curiously described it as a "carrot-shaped mass of flint, spar and chalk, intermingled 8 to 9 feet high, 2 feet in diameter, and standing erect." I do not know of these remarkable formations elsewhere in Yorkshire,* but similar large masses of flint are found in the Chalk of Norfolk and by Sir C. Lyell are called "pot-stones." They also exist in the Chalk near Belfast, and were termed by Dr. Buckland "Paramoudra."

Proceeding westwards along the north boundary of the Chalk range, flint is distributed everywhere, either in tabular layers or in beds formed of nodular masses, much resembling a pavement of irregularly sized boulders, or in horizontal lines of detached nodules, and always accompanied with a few lumps of various sizes scattered broadcast in the mass. The same section often presents the whole of these forms. From base to summit, these different forms and arrangements of the silica in the Chalk are observed; yet no two sections, even of the same horizon, present exactly the same appearance, and the variation is sometimes considerable, even in a limited area, as a few extracts from my note book will suffice to show.

1st. At the foot of the Chalk range opposite Speeton and Reighton are large masses of flint of various forms.

2nd. A pit on the high ground just to the south of Reighton exposes several thick tabular beds, each consisting of several thin layers of flint, much mixed with chalk, lying one upon another, but not united, *i.e.*, parted by films of fuller's-earth or a little chalk.

* Since writing the above, I discovered, August 15th, 1876, a similar specimen protruding from the face of a large chalk pit at the south end of Thixendale. It consisted of flint mixed with flinty chalk, and measured 6 feet high, 3 feet in diameter near the bottom and 4 feet near the top. Its bottom was rounded in the form of the underside of an hemispherical dish or bowl.

One of these compound beds measured in several places from 9 to 10 inches in thickness.

3rd. At the lime-kilns, about a mile away from the last mentioned pit, on the road to Hurmanby, the silica assumes the form of nodules only, either arranged in horizontal lines or distributed at random through the Chalk. They are of all sizes and shapes, the larger having commonly several pointed branches shooting out in various directions.

4th. Passing onwards to the foot of the Wolds, within half-a-mile of Muston, a large pit shows two beds, each about 9 inches in thickness, and seven others from 1 to 8 inches in thickness. In addition to these are several somewhat round and flat nodules and many-pointed oddly-shaped lumps, some distributed in horizontal lines and others scattered at random in the Chalk. Under the lower thick bed above-mentioned, in places extending a distance of several yards, is a thin bed of banded flint separated from the thick bed above by a little fuller's-earth, and in some places by a little chalk, varying from one-eighth to three inches in thickness. From here, along the foot of the Wolds, close to the south of Folkton and Flixton, flint exists in abundance.

5th.—Further westwards, in a large pit, about one mile S.E. of Wharram-le-Street, and in another pit on the west brow of Acklam Wold, the flint is rather sparingly distributed in detached nodules of every form, and varying in size from a pea to a large pumpkin. Here, as in some other places, the flints are coated with a leathery-looking skin or substance, whilst the interior is mostly of a light colour, and more or less variegated.

6th.—A pit close to the village of Bainton exposes the Chalk to a depth of 30 feet, midway through which runs one horizontal bed of small detached nodules of flint. There is here an almost vertical fissure, varying from two to five inches in width, extending from top to bottom of the pit. The portion below the horizontal flint-bed above-mentioned, is charged with detached nodules, resembling those in the horizontal bed itself; but above this bed the fissure is filled with crumbled and disintegrated chalk, without the slightest trace of flint. These oblique veins of flint are of rare occurrence in the Chalk of Yorkshire. I only know of three other examples—one at Fimber, one at Fridaythorpe, and one at Silex Bay, all of which are of small extent.

I need only mention further that at Bishop Burton, Cherry Burton, Etton, Blue Pits, Little Weighton and Hessle (which last is the southern limit of the Yorkshire Chalk), flint exists in all the forms

which I have named, and in great abundance. Along the west boundary a similar development of flint may be noted. Seams of flint, made up of knotty projections, are in some places very irregular in form, and at short distances vary from 2 to 20 inches in thickness.

For a knowledge of the existence or non-existence of flint in a portion of the Chalk area which lies beneath the Glacial Drift of Holderness, I am indebted to Mr. Villiers, of Beverley, who has kindly given me a list of borings made under his supervision. The cross shading on the map in the neighbourhood of Hull mark the site where flint is found. "At Beverley Parks," he says, "at Cottingham, Hull town, and Hull Gaol, Hessle Road, and St. John's Wood (Hull), beds of flint are found 3 to 4 feet apart. At Molescroft the beds are very thin." He adds, "In the neighbourhood of Hull the flint is met with as soon as the Chalk is reached, in beds about two inches in thickness, and some distance apart; but in passing downwards, these beds increase in number; and at a depth of 150 feet in the Chalk, they are 6 inches or more in thickness. Below this level the flint-beds diminish in importance, and at a depth of 300 to 400 feet they are very thin and far between." At Marfleet, about one mile to the east of Hull, the flint runs out." He has not observed flint in any other part of Holderness.

THE FLINTLESS CHALK rises from beneath the Tertiary and Post-Tertiary beds of Holderness, and acquires a considerable width at its northern limits, as is shown on the map, but in coming southwards its surface area narrows considerably. It underlies the whole of Holderness. At Dunnington it is met with at a depth of 120 feet beneath the surface. At Hornsea-Burton near the sea, at 139 feet; at Hornsea town at 108 feet. At the last-mentioned place it has been bored completely through, and its ascertained thickness at this spot is 800 feet, resting on blue clay or shale. Here, as in all other borings in Holderness (except the few in the immediate neighbourhood of Hull), *no flint* has been observed.

The structural characteristics of the Flintless Chalk may be best observed in the fine coast section, commencing about one mile to the north of Bridlington Quay, and extending to Silex Bay, opposite to the lighthouse of Flamborough. On Sept. 30th, 1874, Dr. Wood, Mr. Sterricker, and myself, walked along the beach, and closely examined the face of the cliff between these points, without finding any trace of flint, with the single exception of one solitary lump of cherty flint, found in the midst of a closely-packed accumulation of broken-up *Inoceramus*, *Ostrea* and other shells,

situated about a quarter of a mile S.W. of the south end of Danes Dyke. Near the south landing, Flamborough, I noticed, in a limited area, several similar accumulations of broken shells, cemented together with chalky matter, but without the cherty substance. These heaps appear to be from 2 to 4 feet in diameter, and from 2 to 6 inches in thickness. They are at a height of 6 or 8 feet from the base of the cliff. A close inspection would probably result in the discovery of others at various elevations. I am of opinion that these nests of crushed shells may possibly be the ejectamenta of shell-crushing Cestracionts of the Cretaceous Sea, and if so, mark their frequent lairs as clearly as the old "Kjokken-möddings," or shell-mounds, mark the site of primitive Danish and other settlements. We also observed an unusually large amount of Iron Pyrites, especially in the north-eastern half of the above-named section, which has in part gathered round sponges and other organic remains, and in part occupied the spaces left by their decay.

It is now quite obvious that this very thick mass of Flintless Chalk, which forms the substratum of the whole of the Holderness basin, and which rises to the surface at its northern and western margins, must be either, 1st, posterior to, or, 2nd, contemporaneous with the thick flint-bearing beds by which it is fringed, and with which it gradually intermingles through the area shown on the map by the narrow irregular strip of blended colours. If posterior, it is quite the reverse of the order of deposit observed in the Chalk of the South of England, though I believe almost identical with that assigned to the Chalk formation in Ireland If contemporaneous, there is to my knowledge no mention of a parallel case in England.

Separating, as I have before intimated, the Chalk with much flint, from the Chalk without any flint, is an area varying from 1 to 3 miles in width where the two kinds dovetail, and are gradually incorporated with each other.

Proceeding northwards from the most southern point of this area, and exploring the pits along its course, we find, at first, that in an extensive pit at the Victoria Works on Beverley Westwood, 150 feet above the sea level, or Ordnance datum line, and in a bore at Beverley town, reaching 72 feet below the sea level, no trace of flint exists; but at the Grand Stand, on the N.W. margin of Westwood, and at Park House moat, 1½ miles further north, 130 feet and 75 feet respectively above the sea level, flint is sparingly distributed in scattered lumps. Whilst at Bishop Burton and

Cherry Burton, 1½ miles to the west, and 150 feet above the sea level, flint abounds.

In a pit just to the south of Bainton, at an elevation of 127 feet, flint is observed, though in comparatively small quantity; whilst in a pit one mile to the east, in a line with Burn Butts, only 7 feet lower than the last-mentioned pit, it has entirely disappeared. About one mile north of Bainton is a pit (174 feet) containing a small proportion of flint, whilst, again, about one mile to the east, a pit (150 feet) is quite free from flint.

Further north, and on the east side of Tibthorpe Wold Farm, adjoining the Beverley Road, is a pit (225 feet) containing a medium quantity of flint; whilst this time, considerably to the west and N.W., in a pit (225 feet), just to the east of Gameslack Farm-house, and in another (487 feet) a little south of Life Hill, no flint is found. But only half a mile to N.W. of these points, at elevations ranging from 225 feet to 500 feet above the "datum line," flint is tolerably abundant everywhere.

At Cowlam and Weaverthorpe Pasture, 500 feet to 525 feet above the sea, flint is sparingly and irregularly distributed. To the south and S.E. of these points no flint has been observed, except when deepening a well at Langtoft during the autumn of 1874, when it was met with at a point only 100 feet above the sea level. At Kilham, a little further S.E., several borings were made, during the dry summer and autumn of the above year, to within 25 feet of the sea level, without touching any flint.

In a large pit close to Weaverthorpe, on the road to Butterwick, the beds of Chalk and flint stand on edge, and treand nearly east and west; but in another extensive pit by the roadside, half a mile further east, the strata are nearly horizontal. Both pits contain a medium proportion of flint. South of this place the flint soon disappears. At the north end of the village of Foxholes the strata are much folded, showing short steep inclinations (much resembling those sharply curved strata in the cliff at Bempton, and of which it is probably a continuance), alternating north and south. Here flint is found in broken beds and in detached nodules. South, again, the flint soon disappears.

At Fordon, in the valley near the church (226 feet), and also a quarter of a mile south, on the brow of the hill (350 feet), flint is found in tabular beds and in detached nodules. From here it rapidly diminishes, and about one mile south of Fordon, and a quarter of a mile north of Wold Newton, a large pit, giving a section over 40 feet in elevation, shows no trace of flint.

In the railway cutting one mile south of Hurmanby Station, at an elevation of 250 feet, flint abounds, whilst at Caddy Barf Barn, in a pit by the railway (225 feet), one mile further south, there is no flint; but half a mile east it is again found in abundance, at elevations ranging from 300 feet to 400 feet. Proceeding along the railway towards Bridlington, 275 feet to 300 feet above the sea level, no flint is found, either in the cutting or in the pits in the adjoining fields; but half a mile to the east at Speeton Bempton, and on to Flamborough, in pits ranging from 300 feet to 400 feet above the sea level, flint is found in great quantity. From the north landing, Flamborough to Silex Bay, flint rapidly diminishes, and in the same beds of Chalk—which are here nearly horizontal—a little further south ceases altogether.

After a careful inspection of numerous pits along the connecting margins of the two Chalk areas, I am persuaded, much against previous impressions, that the flint-bearing and non-flint-bearing Chalk areas are in the main contemporaneous in Yorkshire, and that the diminution and final running out of the flint takes place, all along the inner margin of the area shown on the map by small circles, in a horizontal direction, there being no trace of an overlying; but in some places only the flint extends further inwards in the lower beds of Chalk than in the upper. This oblique termination is not clearly visible in the coast section.

Now, that a rim of flint-bearing Chalk should encircle an area of non-flint-bearing Chalk is a geological puzzle, which becomes infinitely more perplexing when we find, from a series of careful analyses, that this Chalk without flint contains as much as 4·28 per cent. of silica, whilst the Chalk with flint contains only 2·12 per cent. Why this silica should so form into flint in one portion of the Chalk and not in another, and what are the conditions which induce this disseminated silica to thus aggregate, are questions of deep scientific interest, to be solved, apparently, by the chemist only.

PART II.

(Abstract).

In the second portion of the paper the author recapitulates the conclusions of the first portion, and expresses his intention of speculating upon the facts therein recorded.

1st. As to the relative age of the flint.

2nd. As to its mode of formation, and the cause of its numerous shapes.

A. In disposing of the first proposition it is necessary to show whether the formation of flint is, or is not, contemporaneous with the chalk beds in which it is found, and with which, when bedded, it is (with rare exceptions) conformable. He concludes that both the tabular layers and the more isolated forms are not, like the thin seams of fuller's earth, of the same age as the chalk—*i.e.*, the silicification is subsequent.

B. In dealing with the second proposition he adduces certain forms most distinguishable, viz.:—

1. Casts of interiors.
2. Forms due to the growth and decay of submarine plants.
3. Casts from cavities left by various fungiform and other fucoidal masses.

He also notices a bark-like covering, which may be the remains of the skin of the fucoid, and concludes that the horizontal beds and tabular masses of flint are the filled-in hollows left by the decomposition and dissolution of large sheets of fucoids. These mark periods of excessive growth, after which they were covered up with chalk mud, then decayed away, and were after a time replaced in form and outline by silica.

C. This is effected by infiltration, the result of the collection of silica from the general mass of chalk. The segregation of the molecules of silica proceeds till "arrested by cavities left by the wasting away of animal or vegetable tissues, and there held in chemical union with kindred molecules left by these decaying organisms." This, however, only takes place under certain conditions; for, if the process were constantly going on, we should have the greatest accumulations of flint in the very lowest beds of the Chalk, which is by no means the case always. Before this process or action is set up, the molecules of silica and lime carbonate throughout the Chalk, are only in mechanical union, as is the case with these same substances in the interbedded fuller's earth. But under certain conditions, which the author does not venture to suggest, a more intimate union between the molecules of silica is effected, and flint thus formed.

D. *Peculiarities of flint.*—Veins of flint, though very rare, bear out the infiltration theory—Bainton vein.

Banded flint due in a great measure to the replacing of decaying tissues of animal or vegetable bodies—the tissue arrangement only visible where the silica is variably charged with colouring matter.

Flint a pseudomorph after organic forms, and not after amor-

phous carbonate of lime, or other inorganic substances. Alluding to the interception of shells, ventriculites, and all kinds of minute organisms in flint, he explains it by such bodies having settled and become enveloped in the growing fucoid.

E. Where the flint-bearing area merges into the non-flint-bearing the calcareo-siliceous masses are more numerous than those of pure flint, ranging from 20-80 per cent. silica. In addition we find nearly pure lime carbonate taking every form of flint throughout the flint-bearing as well as the non-flint-bearing Chalk. The subtraction of a portion of the silica for the formation of flint explains the difference between the 2 and the 4 per cent. silica in the respective chalks; that in the flintless portion remaining in the same condition as when originally supplied to the accumulating sediment.

But this non-aggregation of silica in the flintless Chalk is not due to the want of forms, the results of the decay of animal and vegetable substances, as sections will disclose shapes resembling every form of flint, including even banded specimens. These forms, like the flints, are due to casts from cavities left by the destruction of organic substances.

Some of these, like the flints previously mentioned, are coated with a brown leathery substance, which the author considers to be the remains of the cuticle; this leathery coating defines the true shape and size of the body.

Since writing the above, the author has read Professor Rupert Jones' paper on "Quartz, Chalcedony, Agate, Flint, Chert, Jasper, and other forms of Silica Geologically Considered." The leading theory propounded he has a difficulty in believing; and considers it should be shown how amorphous lime carbonate can be replaced by silica, whilst calcite and arragorite are not. Also that the whereabouts of the displaced chalk should be accounted for. In the Speeton section of 350ft. the flint is equal to 24ft. vertical.

The direct infiltration into susceptible cavities, formed by organic decay, is the more simple explanation.

In fact, this simple and everyday process of nature is not only designed to explain the formation of flint and other aggregations of silica, but of nearly every size, form, and peculiarity of nodular or amorphous mass, in every aqueous deposit, from the dawn of plant and animal life to the present epoch.

ORDINARY MEETING, March 1st, 1878.

Professor Morris, F.G.S., President, in the Chair.

The following Donations were announced :—

"Quarterly Journal of the Geological Society of London," Vol. xxxiv., Pt. 1, No. 133; from that Society.

"Abstracts of the Proceedings of the Geological Society of London," Nos. 346 and 348 ; from that Society.

"Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire," N.S., Pt. iv., 1877 ; from that Society.

"Journal of the Society of Arts," Nos. 1316-9; from that Society.

"Thirlmere Defence Association—Manchester and Thirlmere Water Scheme ;" from B. B. Woodward, Esq.

The following were elected Members of the Association :—
C. N. Octavius Curtis, Esq.; Joseph Gundry, Esq.; Thomas McKenny Hughes, Esq., M.A., F.S.A., F.G.S., Woodwardian Professor of Geology, University of Cambridge; D. L. Lawson, Esq., M.A.

The following Papers were read :—

1. On the New Town Well at Sheerness.

By William H. Shrubsole, Esq.

(Abstract.)

A well of a greater depth than any other in the Isle of Sheppey having been recently sunk to obtain a larger water supply for Sheerness, the author brought before the Association the geological facts recorded, during the progress of the work, by himself and his friend Mr. Boughey.

After breaking the surface, and getting through three feet of made ground, dark blue to black mud was met with down to 47 feet, passing at 30 feet a layer of peat, just below which were roots of grasses and aquatic plants. At 47 feet, a band of flints, bedded in pale-brown, almost yellow loam, rested on the London Clay at 48 feet. Light-brown at first, and then streaked

with blue, at 67 feet the clay was of a pale blue tint, changing to a warm-brown on exposure. It continued of uniform close fine texture and appearance down to 157 feet. Some of the septarian nodules found on the way had a quantity of water in the internal crevices, although the clay around them was quite dry, as indeed was the case right through. At 157 feet the clay, still of the same colour, began to come up in very large blocks, and the fossils found were flattened as if by pressure.

To connect the two wells, a heading was begun at 200 feet. Here a sub-angular fragment of white-coated flint, and a well-rolled chalk pebble were met with. At this depth *Nodosaria costata* was found. After careful washing, by means of an elaborate process, which was described in detail, a cart load of clay was thoroughly examined by the author. This clay was selected from all that was excavated from a shaft 7 feet in diameter by 335 feet deep. From the heading at 200 feet down to 280 feet, the washings yielded 60 species of Foraminifera, particulars of which are appended.

At 220 feet the clay came up much more shaly and brittle, broken up in conchoidal wedges. Two feet further down, evidence of disturbance was met with for the first time. The clay was polished and striated on every surface, wherever broken. All the lines of bedding were thus polished. In some of the joints it was broken up into very small cubical splinters, all of which presented the same appearance.

At 230 feet from surface, the clay had changed to a grey slate colour, and was deficient in the feeling of greasiness that had characterised it previously. Here was found a seed corresponding to Bowerbank's *Leguminosites*. On splitting open the clod containing this seed, the outer integument burst open and peeled off before it had been one minute exposed to atmospheric influences. It may be noted that apart from exogenous wood in various conditions, and another seed found by Mr. Boughey, no other representative of the vegetable kingdom was met with. The almost entire absence of fruits, and the complete absence of those of endogenous trees in such a large excavation as this, where other fossil remains were found in considerable number and variety, demands further consideration.*

* Close by, the Sheppey cliffs exhibit, for a length of six miles, a section of the upper 150 feet of the London Clay. There, on the beach, with other

A marly character was observed at 240 feet, and the clay became gradually harder and darker in colour down to 280 feet. Here perfect specimens of Foraminifera were lost sight of, but chalky patches and seams, sometimes nearly an inch thick, attested their former plentiful existence. Occasionally the outline of a specimen was sufficiently preserved to admit of identification. This continued down to 335 feet, when a greenish tint and a little intermingled sand betokened nearness to the bottom of the clay. It should be mentioned that at and below 293 feet the clay was studded with very minute discs of iron pyrites, each having a boss in the centre, and the edge slightly turned up all round. They were uniformly perfect, as much so as if cast in one mould. At this stage the workmen returned to the unfinished heading, at 200 feet. The difference in the clay was strikingly apparent. The changes downward had been gently graduated; here clay of lighter tint suddenly recurred, softer, moister, and much greasier than that left at 335 feet. Forams were found again throughout this heading; most abundantly about half-way through.

After completing the communication between the two wells, the workmen commenced boring from the bottom of the shaft. The clay became more sandy till the bottom was reached at 338 feet. Here a hard crust of greenish sand was encountered, and the chisel had to be brought into use, proving clearly that the Lon-

things are found, to the extent of several hundreds weekly, fruits of many genera, *Nipadites* being much more plentiful than any other fossil, either of vegetable or animal origin. As Prof. Prestwich tells us there is evidence to prove that the condition of animal life was similar at the end to that which existed at the commencement of the London Clay period, it might also be expected that indications of equal uniformity in the vegetable kingdom would be found. The entire absence of *Nipadites* and other endogenous fruits was rather surprising, and led to the enquiry if any had been found where sections of the lower part of the London Clay have been exposed.

Between Herne Bay and Oldhaven Gap, where the cliffs present a large section of the lowest part of the London Clay, cones, named by Bowerbank *Pterophiloides*, which in Sheppey are extremely rare, have been at times found in large numbers; the author is not aware that endogenous fruits have been met with there or elsewhere at the same horizon. The question arises whether or not this evidence that conifers flourished at the beginning, and palms at or near the close of the London Clay period, indicates climatic variations of considerable range?

Although Sir Charles Lyell states that it is in the uppermost 50 feet of the Sheppey cliffs that the fruits are chiefly found, the author is unable, after nearly 30 years acquaintance with these cliffs, to find any reason why 50 feet should have been assigned as the limit. Having found them *in situ* at the base oftener than higher up, he submits that the 50 should be enlarged to 150 feet, which may be taken as the average height of the cliffs.

don Clay had been left behind. The green colour of the clay near the junction is due to chloritic grains.

Of the mineral substances found in the clay, the most abundant were the well-known septarian nodules, which on being burnt and ground produce Roman-cement. Some, as has been elsewhere noticed, contained water, which flowed out on the crust being cracked. There were also concretions that the workmen called "clay-stones." These generally had a very hard core, and a nucleus of organic origin could often be made out. A problem to be solved in connection with these is the hardening of the clay upon and around them in concentric layers There were also a few angular fragments of flints, and two or three pebbles, also one or two pebbles of chalk. Neither iron pyrites nor selenite was so plentiful as was expected. The Molluscan and other organic remains are not pyritized to the same extent as those from the higher level, and many are not impregnated with iron at all. Indeed, the cliff specimens are no longer shells, but pseudo-morphs in pyrites. The shells from the well, on the contrary, are comparatively unaltered. Another point of difference is that where the shell has decayed since being exposed, a cast in clay—not pyrites—is presented. These facts show that pyrites was by no means abundant at the well sunk.

Almost without an exception, the shark's teeth, that are most abundant in the cliffs, have the fangs perfect, while the few teeth met with in the London Clay of the well were in every case without fangs, and the crown of the tooth was hollow.

The Lower London Tertiaries were marked by continual alternations of sandy loam, and loamy sand of various tints. There were few fossils. In the Woolwich and Reading Beds were *Cyprina planata* and teeth of *Lamna*, and these were all. The variations observable in the sections of the Dockyard and Garrison wells are very peculiar, and seem to point to great irregularities in bedding.

Keeping to the new Town Well, at 500 feet, two feet of the usual green-coated flints, bedded in clay, were met with, and at 502 feet Chalk was reached for the first time in Sheppey. At 750 feet a fissure was reached which promises to yield a most abundant supply of water. The boring was afterwards continued to 805 feet, but the last 30 feet was in a kind of Chalk-marl where there was little prospect of finding more water. This marly chalk was very tenacious, and on being washed yielded

a considerable proportion of sand. When the pumps are at rest the water now stands in the two connected wells at 85 feet from surface. The water level in the 1862 well at first was 37 feet. It fell by slow degrees to 100 feet, till the influx from the new well raised it to 85 feet.

In the determination of the fossils the Author had the valuable help of Messrs. Etheridge and E. T. Newton, of the Geological Survey; Mr. J. Siddall, of the Chester Natural Science Society; and the Rev. J. F. Blake, M.A.

LIST OF FOSSILS FOUND IN THE LONDON CLAY.

PISCES.
Teeth of Lamna elegans.
Scales, ear-bones, and vertebræ of fish.

CEPHALOPODA.
Nautilus.

GASTEROPODA.
† Buccinum labiatum.
* Dentalium acuticosta.
Fusus bifasciatus.
„ sp.
Natica.
Phorus extensus.
Turritella.
Voluta Wetherelli.

LAMELLIBRANCHIATA.
* Arca sp. allied to A. impolita,
Avicula papyracea.
Corbula.
* Cryptodon angulatum.
„ Goodhallii.
Leda amygdaloides.
* „ prisca.
Nucula Bowerbankii.
† „ striata.
† Ostrea edulina (young).
* Pecten duplicatus.
† Plicatula (fragment.)
Syndosmya splendens.
† Tellina sp. Probably an undescribed species.
Teredo antenautæ.

BRACHIOPODA.
* Lingula tenuis.
Terebratulina striatula.

POLYZOA.
† Flustra sp. allied to F. pertusa.
† Idmonea sp. allied to fenestrata.
† Lepralia, new? similar to punctu-rata or to maceocheila (Reuss).

CRUSTACEA.
Archæocarabus Bowerbankii
* Bairdia subdeltoidea?
* Cythereis Bowerbankiana.
* Cytherella compressa.
* Cythere scrobiculostriata.
* Cytheridea perforata.
Hoploparia Bellii.

ANNELIDA.
* Ditrupa plana.
* „ sp.
* Serpula.
† Spirorbis sp.

ECHINODERMATA.
Astropecten.
* Cainocrinus tintinnabulum.
Arms and pinnulæ of crinoids.
Marginal plates of Goniaster Stokesii.
Pentacrinus sub-basaltiformis.
Fragments and plates.

ACTINOZOA.
Graphularia Wetherellii.

PLANTÆ.
Leguminosites (one specimen).

FORAMINIFERA.

† Cornuspira involvens; exceedingly rare.
† Triloculina trigonula; rare.
† Quinqueloculina seminulum; rare.
† „ Ferussacii; rare.
† „ secans; rare.
† „ bicornis; very rare.
† „ agglutinans; very rare.
† Spiroloculina excavata; exceedingly rare.
† Spiroloculina planulata; rare.
* Trochammina inserta; rare.
† Lagena marginata; frequent.
† „ sulcata; rare.
† „ globosa; rare.
† „ melo; very rare.
† „ striata; very rare.
† „ lævis; very rare.
† „ aspera; very rare.
† Glandulina glans; exceedingly rare.
† Nodosaria radicula; frequent.
† „ adolphina; common.
* „ raphanus; abundant.
† „ longisecta; frequent.
* „ ovicula; frequent.
* „ pyrula; frequent.
† „ scalaris; exceedingly rare.
† „ hispida; exceedingly rare.
* Dentalina pauperata; common.
† „ obliqua; frequent.
† Vaginulina legumen; rare.
* Marginulina Wetherelli; very abundant
† „ glabra; very rare.
* Cristellaria Italica; abundant.
* „ rotulata; abundant.
* „ crepidula; very rare.
† Uvigerina pygmea; very common.
† Bulimina pyrula: frequent.
† „ pupoides; frequent.
† „ variabilis; rare.
† Virgulina squamosa; exceedingly rare.
† Textularia variabilis; rare.
† „ saggitula; frequent.
† „ difformis; frequent.
* „ agglutinans; common.
† Bigenerina nodosaria; abundant.
Verneuilina Muensteri; frequent.
† Gaudryina muensteri; frequent.
† Orbulina universa; rare.
* Globigerina bulloides; frequent.
† Nonionina umbilicatula; frequent.
† „ communis; exceedingly rare.
† Discorbina rosacea; common.
† „ globularis; rare.
* Planorbulina Ungeriana; common.
* „ ammonoides; common.
* „ Haidengerii; common.
* Truncatulina lobatula; frequent.
† Rotalia Soldanii; frequent.
† „ Beccarii; frequent.
† Cymbalopora Poyei; exceedingly rare.
† Polystomella striata punctata; exceedingly rare.

* New to Sheppey	... ...	30
† „ „ London Clay	... ...	54
Sheppey species previously known	...	25
		—
Total of species found...	... ...	109

Pisces	... 2	Gasteropoda	... 8
Cephalopoda	... 1	Lamellibranchiata	... 15

Brachiopoda	... 2	Echinodermata	... 5
Polyzoa	... 3	Actinozoa	... 1
Crustacea	... 7	Foraminifera	... 60
Annelida	... 4	Plantæ	... 1

Of the Foraminifera.

9	species	were exceedingly rare.	7	species	common.
8	„	very rare.	1	„	very common.
13	„	rare.	1	„	very abundant.
17	„	frequent.	4	„	abundant.

Nodosaria costata was the first species seen. *Trochammina incerta* was very rare at first, but lower down many solitary individuals were found, after perfect specimens of other species had been lost sight of. *Marginulina Wetherelli* was by far the most abundant.

Copy of Report on New Well, 1876-77-78, supplied to Sheerness Board of Health, by Mr. T. Tilley:—

Feet.		Description of Strata.	Feet.	
3	0	Made ground	3	0
12	8	Blue soft mud	9	8
15	8	Black soft mud, with vein of sand on top	3	0
44	0	Blue soft mud	28	4
46	0	Black peaty mud and water	2	0
47	0	Light yellow clay and flints	1	0
70	0	Dull red clay	23	0
273	0	Blue London Clay, with Septaria	203	0
338	0	Dark-blue London Clay, with pyrites and wood ...	65	0
346	0	Green sandy rock with very little water	8	0
354	0	Grey sandy rock, with fossils and little water ...	8	0
359	0	Dark sandy crusty rock, with pebbles	5	0
362	0	Dark clay, with lignite on top	3	0
364	0	Reddish sand, with a little water	2	0
369	0	Hard red sand-rock, with veins of pyrites and a little water	5	0
370	0	Very light sand-rock, with a little water	1	0
372	0	Dry sandy loam	2	0
383	0	Greenish sand, pebbles and pyrites	11	0
385	0	Very hard, tough, dark-green clay	2	0
395	0	Grey sand, with pyrites and beds of sand-rock. Good spring of water which rose to height of 160 feet from surface while pumping was going on... ...	10	0

Feet.			Feet.	
400	0	Green sandy loam	5	0
412	0	„ with shelly rock, pebbles and some water	12	0
425	0	Grey loamy sand, rotten shells and fish teeth ...	13	0
440	0	Loamy sand and rotten shells	15	0
443	0	„ and pyrites, and vein of sand with water	3	0
448	0	„ and rotten shells	5	0
470	0	Sandy clay and sand stones	22	0
471	6	Dark-green sandy clay	1	6
502	0	Brown sandy clay, the last two feet being flints bedded in clay	30	6
503	0	Flints and Chalk	1	0
553	0	Chalk rubble, with dirty vein or pot-hole	50	0
670	0	White solid Chalk with flints; a little water at 670 feet	117	0
715	0	„ „ no water	45	0
728	0	„ „ „ „	13	0
738	0	Yellow gritty Chalk, with flints. At 738 feet water rose over the bore pipe to 100 feet from surface, and flowed for two hours while the pumps were going	10	0
750	0	Chalk with flints, and fissures with good supply of water	12	0
770	0	White Chalk with flints	20	0
773	0	Small fissure in Chalk, with flints and a little water...	3	0
805	0	Hard, dull, sticky Chalk, apparently leading to Grey Chalk, from which no water is to be expected ...	32	0
			805	0

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2. On Some Recent Discoveries among the Spongidæ—Living and Fossil.

By W. J. Sollas, Esq., B.A., F.G.S.

(Paper Deferred.)

VISIT TO THE BRITISH MUSEUM.

SATURDAY, MARCH 16TH, 1878.

Director: — Dr. GÜNTHER, F.R.S.

(DEMONSTRATION ON CERATODUS.)

Report by Dr. J. FOULERTON, F.G.S.

The CERATODUS is a living representative of an old form of fish, belonging, like *Lepidosiren*, to the Dipnous division, as established by Muller. All fishes, up to the Mesozoic period, called the Palæichthyes, viz., the Ganoids (including Dipnoi and Selachians) have three very marked peculiarities in common, viz., a triple heart, non-decussating optic nerves, and a spiral valve in the intestine: they resemble each other much more than they do the present Teleosteans.

The Teleosteous fishes of the present day have a heart without contractile conus arteriosus, but in the Palæichthyes there is a third contractile chamber above the ventricles, with rows of valves, the exact function of which is not quite understood, as though numerous, they seem too small to prevent regurgitation.

The Optic nerves in modern fishes decussate, which they do not in any of the living Palæichthyes, and, presumably, did not in their fossil representatives. In the Palæichthyes the intestinal tube is a short, straight tube, which would not have provided a sufficiently large surface for the absorption of nourishment, were it not that this is much increased by a spiral fold, which extends along its internal surface. In *Ceratodus* this fold makes nine turns round the intestine. In fossil casts of the intestine of these fishes the folds are indicated.

So much then for these three important characters which the Ganoids, the Dipnoi, and the Selachians have in common. I will now call your attention to some of the other organs.

The *Ceratodus*, like the *Lepidosiren*, has true lungs, as well as gills, so that it is really amphibian in this respect. Queensland—the habitat of the *Ceratodus*—like tropical Africa and America—the habitat of the *Lepidosiren*—is subject to droughts, which destroy many of the ordinary fishes, but which these Dipnoi are enabled to survive, owing to this peculiarity of their organization. In *Cera-*

todus the lung is not divided, as it is in the Amphibia, but there is an indication of such a division.

In *Lepidosiren* the front and hind limbs—true limbs, not fins—are long and filamentous, whilst in *Ceratodus* they are broader and paddle-shaped, enabling the animal to progress on a muddy bottom. This difference in external appearance has a corresponding difference in the cartilaginous framework, the single row of jointed cartilages in *Lepidosiren* being furnished with numerous jointed rays in *Ceratodus*. The bones attached to the notochord have this peculiarity, that they are perfectly solid, and consist of an inner rod of cartilage, with an outer covering of bone, which accounts for the fact that in the fossil state they are hollow, the cartilage having disappeared, and only the bony case left.

In the Selachians the limbs have a similar cartilaginous framework, but the rudiments of fingers are arranged round the base. The scales of *Ceratodus* are cycloid in form—large and thin, like those of the carp—showing how unimportant a character the structure of scales is as a means of classification. The mouth is narrow, and the anterior nostrils, both in *Ceratodus* and *Lepidosiren*, are partially covered by the lips, whilst the posterior is quite within the cavity of the mouth.

The teeth of *Ceratodus* consist of two strong molars attached to the palate, two corresponding molars in the lower jaw, and, in addition, two small incisor-like vomerine teeth in the upper jaw. These teeth, having no bony attachment to the jaw, are found by themselves in a fossil state, and it was from them that this family of fishes was first known. When Agassiz saw one of these fossil teeth he rightly predicted that there would be only one pair in each jaw. These teeth might be either for crushing shells or masticating vegetable food, but I have always found the latter in the stomach of *Ceratodus*. In *Lepidosiren* the teeth are quite different, being short and sharp, and adapted for seizing the animals on which it preys. The spinal column of *Ceratodus* is a cartilaginous rod, not divided into vertebræ, and is called a notocord. It could not be preserved in a fossil state.

The *Ceratodus* is called the Mary Salmon in Queensland, being about the size of a good large salmon with similarly coloured flesh, and it was the circumstance that the Hon. W. Forster told Mr. Krefft, of the Museum of Sydney, that the Mary River was inhabited by salmon with pink flesh, which were excellent eat-

ing, that led to the discovery of the animal. At some considerable trouble and expense, he brought a specimen to Sydney, which Mr. Krefft at once pronounced to be a *Ceratodus*.

Finally, Dr. Günther directed the attention of the Members of the Association to the remarkable fact that the geographical distribution of the Dipnous Ganoids closely coincides with that of a Teleosteous family, viz., the Osteoglossidæ; the Ganoid *Protopterus* being accompanied by the Teleosteous *Heterotis*, in tropical Africa; *Lepidosiren*, by *Sudis*, in tropical America; and *Ceratodus*, by *Osteoglossum Leichardti*, in tropical Australia, therefore he could not hesitate to predict that a dipnous fish, probably closely allied to *Ceratodus*, would, before long, be discovered in Borneo, an island in which *Osteoglossum formosum* is of common occurrence.

VISIT TO THE BRITISH MUSEUM.

BOTANICAL DEPARTMENT.

MARCH 23RD, 1878.

Director—W. CARRUTHERS, ESQ., F.R.S., Keeper of the Department.

(*Report by* G. S. BOULGER, ESQ., F.L.S., F.G.S.)

Some twenty or thirty Members assembled in the private inner rooms of the Department, where the Director explained the history and arrangement of the herbaria under his charge. The arrangement followed is that of De Candolle's *Prodromus*, only the British and Sloane collections being kept apart—all others are gradually distributed into the general herbarium. No poisoning is used to keep off insects, but the plants when once thoroughly dried, are placed in well-fitting cabinets, in which are large pieces of camphor. The Keeper said that, after twenty years' experience, he found that very few plants suffered from the depredations of insects, except some of the Leguminosæ.

The collection of Sir Hans Sloane, purchased by the nation rather more than a century ago, is comprised in 300 volumes. It was commenced by Sloane when he was a surgeon in Jamaica, many of his plants being figured in his History of Jamaica. He also obtained many other collections, including that of Kæmpfer,

a missionary from Japan, and the very valuable collection made by Buddle, and used by Dillenius in preparing the third edition of Ray's Synopsis. These herbaria were shown to the Members, as also was that made by Ray, obtained about fifty years ago from the Apothecaries' Company. Mr. Carruthers remarked that Ray's system of classification, being a natural one, his position was higher now than during the last century, when Linnæus' artificial method prevailed.

The original drawings made by James Sowerby, for "English Botany," with Sir J. E. Smith's notes, were next shown. These are preserved in the book-boxes, known as "Solanders," after their inventor, Dr. Solander. They were first used by Sir Joseph Banks in his travels with Captain Cook, and those used by Robert Brown in Australia were also exhibited.

The marvellous drawings of the two brothers, Francis and Ferdinand Bauer, who were supported and pensioned by Sir Joseph Banks, were also examined. These include a series illustrating the development and anatomy of wheat and another of plant diseases, by Francis, who lived at Kew, and one of Australian plants, by Ferdinand, who accompanied Brown. Mr. Carruthers informed the visitors that he had revived Bauer's specimens of the minute annelid, *Vibrio*, known as the paste-eel, after it had been desiccated or "pectously dead" for sixty years. The true nature of "ergot," which is the "sclerotia," or modified mycelial thallus of a fungus known as *Claviceps*, correctly drawn by Bauer, though not understood till about twenty years ago, was also explained, and attention called to the drawings of fungi by Sowerby and Mrs. Russell, and those by Mr. Worthington Smith, illustrating his views of the Potato Disease *(Phytophthora infestans.)*

The company then proceeded to the public gallery, where Mr. Carruthers gave an account of the whole Vegetable Kingdom, from the geologists' point of view. For them, he said, the best division of plants was into "Cellular" and "Vascular." Water and air destroyed nearly all cellular plants, the fossils called Algæ, from palæozoic rocks, not being so in fact. With the exception of some parasitic fungi found in the stems of Lepidodendroid trees from the Coal-Measures, we know of no cellular plants till we come to a true alga in the Tertiaries. The Vascular Cryptogams (Ferns, Club-mosses and Horsetails), occur in rocks of every age, from the Devonian upwards, and have remained most remarkably unchanged through-

out their history; the well-known fern from the Devonian of Ireland being almost identical with the existing Filmy-fern (*Hymenophyllum*). Lycopods were far more highly organised and far larger in stem, foliage and fruit in Palæozoic times than now; they are, in fact, poorly represented in Secondary and Tertiary times; so also the Calamites seem higher than our recent Equisetum; but the spore s ofthese giant trees of Carboniferous times are exactly similar in size and structure to those of the herbs which now represent them. Geologically and botanically the Gymnosperms come between the Club-mosses and the Flowering-plants or Angiosperms, and attention was particularly called to Cycads, represented by fossils from Sussex, Portland and the Isle of Wight, and by the recent genera *Cycas*, from the Old World, *Zamia* from the New, *Ceratozamia* from Mexico, *Macrozamia* from Australia, and *Dion*, a remarkable American genus with stalked antheriferous scales resembling those of the spike of Equisetum. A sub-tribe of Cycadeæ, with berry-like fruit, exists only in a fossil state. Among the Coniferæ, sections of the stem of the Cedar of Lebanon and of the Sequoia or Wellingtonia, a genus which grew in England in Gault and Tertiary times, but is now confined to California, were pointed out; whilst Monocotyledonous specimens, from the Tertiary beds of Antigua, were exhibited as showing rapid silicification, even the leaf-buds being preserved. The Pandanaceæ or Screw-pines occur in the Oolite, and the *Nipadites* of the London Clay of Sheppey belongs to this Order. The Palms only appear in Tertiary times; both types, that with pinnate and that with palmate leaves, occurring in the Bournemouth beds. Noticing in passing the case containing the curious parasites, Mistletoe, Rafflesia and Balanophora, the Director concluded by calling attention to two table-cases, one exhibiting various phases of fossilization, the filling in of dead or decaying organic tissues with lime or silica, the slow combustion of wood, passing into lignite, jet and coal, and the similar effects produced by rapid combustion under pressure, exemplified in specimens from the Tooley-street fire; the other conveying a caution against determinations of fossil plants on the evidence of leaves alone, in the great variability of foliage in the genera *Hakea* and *Banksia*, belonging to the Order named in this account *Proteaceæ*, an Order abundantly represented in our Bournemouth and Isle of Wight Tertiaries, but now mainly Australian.

ORDINARY MEETING, April 5th, 1878.

Professor Morris, F.G.S., President, in the Chair.

The following Donations were announced :—

"Abstracts of the Proceedings of the Geological Society of London," Nos. 349 and 350; from that Society.

"Proceedings of the Warwickshire Natural History and Archæological Society," 1877; from that Society.

"Journal of the Society of Arts," Nos. 1320-4; from that Society.

"Proceedings of the Nova Scotian Institute," Vol. iv., pt. 3; from Dr. Honeyman.

"Transactions of the Geological Society of Glasgow," Vol v., pt. 2; from that Society.

"Proceedings of the Literary and Philosophical Society of Liverpool," Vol. xxxi., 1876-7; from that Society.

"On Fossil Lepidoptera," by the Rev. P. B. Brodie, M.A.; from the Author.

United States Geological Survey, &c. "1st. Descriptive Catalogue of the Photographs of North American Indians."—2nd. "Preliminary Report of the Field Work, for the Season of 1877."—3rd. "Bulletin;" Vol. iv., No. 1.—4th. "Report" [Monographs], Vol. vii.; from Dr. F.V. Hayden.

The following were elected Members of the Association :—

J. W. Judd, Esq., F.R.S., F.G.S., Professor of Geology in the Royal School of Mines; W. J. Sollas, Esq., B.A., F.G.S.

The following Paper was read :—

On Some Physical Properties of Precious Stones.

By Professor A. H. Church, M.A., F.C.S.

Of the various physical properties which may be used to distinguish and identify those minerals which are called gems or ornamental stones, I wish to direct your special attention to two only, to-night, namely pleochroism and specific gravity. I thus limit myself for several reasons. I have some new facts to communicate on these points: these two properties are easily tested without injury to the specimens examined; and the results are obtained in

a decisive form with the simplest apparatus and by inexperienced manipulators. Not that I would wish for a moment to disparage other means and methods of identifying transparent minerals. In the cases to which the process is applicable, what can be more exquisite than Mr. Sorby's new plan for the determination of refractive indices under the microscope? How valuable in certain instances is the aid of the spectroscope, which furnishes us at a single glance with proofs of a stone being a red garnet or a red spinel, a yellow chrysoberyl or a yellow jargoon, though in each case the colour and outward appearance might deceive. The nature of the polished surface of different species of gems offers also another indication of value. This indication may be secured by the sense of touch, at least in some cases. Let the inner aspect of a well-educated human thumb be passed firmly over a polished facet of topaz; it glides softly and uninterruptedly to the end. Substitute as fine a surface of quartz as is attainable by skill of lapidary, and the motion becomes an alternation of slipping and stopping, stopping and slipping, like the crisp feel of starch granules between the fingers. But the nature of these polished surfaces may be investigated by other and more delicate methods than the above rule of thumb. We can determine the polarizing an les* of such surfaces; we can ascertain the distance at which a point of standard light, or a reflected image of some small object (a black triangle being very suitable) becomes extinguished; we can learn by a simple contrivance of moveable plate and graduated arc at what angles the stability of a small weight placed on polished level surfaces of different materials will be overcome. And not to lengthen the list of available properties too much, I can but mention one other characteristic of certain gems, namely, their development of polar electricity by the action of heat.

PLEOCHROISM.—I now propose, in the first place, to enter into more complete details concerning the property of pleochroism, noting, as a preliminary, the construction of the instrument by which it may be most conveniently studied. This instrument, the dichroiscope, was devised by Haidinger, and is now made for about 15 francs by

* Such angles measured from normals are :—

Glass	54°	35′
Rock Crystal...	57	22
Topaz	58	40
Spinel	60	16
Zircon	63	8
Diamond...	68	2

several opticians in Paris. It is, in fact, a double-image prism of calc-spar, fitted into a tube of about $2\frac{1}{4}$ inches in length, one end of this tube being furnished with an adjustable stop, having a square opening in its centre—and the other end being completed by a simple eye-piece, the focus of which is such that it gives a distinct image of the above-named square opening. The length of one edge of the cleavage-rhombohedron of Iceland-spar used is about 1 inch, the other edges being about $\frac{1}{8}$ of an inch each. In the original instrument compensating glass prisms of 18 degrees were cemented to each small end-face of the calcite rhombohedron; but this addition is quite unnecessary if the ends in question be ground perpendicular to the axis of the instrument, and then polished. Thin squares of microscopic covering glass, cemented to the polished faces, and to the inner aspect of the square opening, will preserve the apparatus from injury and dust.

The action of this dichroiscope will be best explained by an illustrated example. We will take the sapphire as our test-object. A slice of this mineral, showing a blue colour, is cut parallel with the principal axis of the prism. We will assume this specimen (and all others spoken of to-night) to be so orientated as to have the principal axis perpendicular to the axis of our dichroiscope. On looking through the instrument we perceive two images of the square opening, the left-hand image being of a pale-greenish yellow, the right-hand image being of a pure velvety ultramarine blue. The light of these images consists of oppositely-polarized and differently-coloured pencils—the two pencils into which the ordinary light transmitted through the rhomb is separated by double refraction. Now the extraordinary ray of these two forms the blue image; the ordinary ray the greenish-yellow image. The latter image consists of light polarized in a plane through the short diagonal of the rhomb while the greenish-yellow image consists of light which is polarized in a plane through the longer diagonal of the rhomb.* Both images together contain the whole transmitted light, but as they share it between them, if the images be made to overlap the part where they coincide, they will not

* The image formed by the pencil of ordinary rays may also be known by its appearing larger and nearer the eye than the other image—the ordinary ray being more lifted up than the extraordinary ray by refraction. If the dichroiscope be furnished with a fine adjustment, and the upper surface of the section of the mineral under examination be ruled or marked, a measurement of this difference between the twc ays may be made by focussing the rules or marks in each image.

only reproduce the original colour of the sapphire, but will also be more brilliant or luminous. This experiment may be shown by rotating the stop, when the neighbouring angles of the two images of its square opening will overlap, and the original light and colour will be reproduced.

Now let us consider how the above phenomena may be utilized in the discrimination of the various transparent blue substances which simulate more or less closely the true sapphire, and which might be mistaken for it. We may dismiss at once from our view the glass or paste and the blue spinel, since these two substances do not polarize the light through them in any direction, and consequently will give two images of identically the same hue in the dichroiscope. But with blue tourmalines and iolites, the case is different. The latter stone images, the iolite or dichroite, shows indigo blue and a buff—the crystal or the instrument requiring with this mineral to be turned through 45° to develop the greatest difference between the two colours. With some blue tourmalines indigo blue and inky grey or greyish-green images are produced, while with those tourmalines which are strongly absorptive of light, the images may alternately disappear during rotation.

A few words concerning the red variety of corundum or ruby may fitly be here introduced. This stone, when of the proper pigeon's blood colour, gives two differently coloured images when viewed in the same way as the sapphire. The ordinary ray is of a flame or aurora-red ; the extraordinary ray gives a crimson or carmine image. Red glass, red spinel, and all the varieties of red garnet, including the beautifully coloured "Cape rubies," so-called, give in each instance two images identical in hue. Now that the ingenious plan has been adopted of mounting a well-cut garnet of blood-red colour between two excellent diamonds, and so arranging a handsome combination where the genuineness of the costly diamonds carries off the falsity of the spurious ruby, it is well to apply the dichroiscope to jewellery of this kind, before giving twice or thrice its retail value for a specimen.

The emerald, and, indeed, all the coloured varieties of beryl, afford excellent specimens for the dichroiscope. A fine emerald is so rare and costly a stone, that it is worth while to know an immediate method of recognizing it, and of detecting the difference

between it and green paste and green garnet. With the emerald the ordinary ray forms a beautiful bluish-green image—like the colour called "viridian"—the extraordinary ray gives an image of a decidedly yellowish-green. With blue beryls the colours are azure and sea-green; with aquamarines green-blue and straw-white. That the two colours of the emerald are distinct, and easily seen, is shown not only by the varied and shifting hues of a well-cut stone of this gem, but also by such observations as the following:—In the magnificent suite of precious stones comprised in the Townshend bequest to the South Kensington Museum, is a splendid faultless emerald (No. 1284), which reveals to the dichroiscope the two hues, although two sheets of glass and a considerable space intervene between the specimen and the instrument. On the other hand one has no difficulty in affirming that a little stone, a so-called emerald, in Mr. J. B. Hope's loan of jewels to the same museum, is nothing but a bit of green glass! A sapphire in the same collection (No. 42), may be similarly proved to be equally worthless.

I must not leave the subject of pleochroism without a reference to the topaz, the chrysoberyl, the amethyst, and the tourmaline. A rich sherry-coloured topaz from Brazil gives two very different hues, one a rose-pink, the other a straw-yellow. The former colour becomes more pronounced, and the latter less so, after the stone has been heated or "pinked," as the lapidaries term the process. If a burnt cairngorm or beryl, or a piece of burnt quartz, be similarly examined, the coloured images are quite different. A chrysoberyl in my collection shows two colours, a greenish-yellow and a golden-brown. A fine dark amethyst shows two hues of purple, one with more blue in it than the other. But the most dichroic of all stones, too distinctly so to need the instrument, is the tourmaline. Many green and brown tourmalines are opaque in the direction of the principal, which is also the optic axis, to light polarized, except what is polarized in a plane perpendicular to that of the axis.*

* Such a tourmaline plate, cut with its face parallel to its optic axis, will divide the ray of common light into two, but the ordinary ray (O) will be completely absorbed, and only the extraordinary ray (modified in colour by the colour of the tourmaline) will be transmitted. The one emergent beam (E) will be polarized in a plane perpendicular to the axis of tourmaline.

The following list includes several examples of dichroism:—

	O.	E.
Sapphire	green-yellow	blue.
Ruby	aurora-red	carmine-red.
Emerald	bluish-green	yellowish-green.
Topaz	rose-pink	straw-yellow.
Peridot	sea-green	brown-yellow.
Aquamarine	grey-blue	straw-white.
Blue Beryl	azure	sea-green.

CRYSTALS.

Uniaxial.*		Biaxial.
Positive.	*Negative.*	
Zircon.	Tourmaline. }	Chrysoberyl.
Quartz.	Rubellite. }	Topaz.
	Sapphire. }	Iolite.
	Ruby. }	Peridot.
	Beryl.	

A good notion of the variety of twin colours, shown by individual specimens of tourmaline, may be gathered from the following list:—

Pistachio-green and bluish-green.
Greenish-yellow and reddish-brown.
Rose-pink and salmon.
Umber-brown and columbine-red.

A properly-cut orange-brown tourmaline shows, from each facet in succession, as it is turned round, a greenish-yellow tint passing into an orange and a brown.

SPECIFIC GRAVITY.—Thanks to Mr. Sonstadt, we have now been in possession for a few years of a ready method of distinguishing many minerals from one another by their specific gravity. To determine this property of a gem by the ordinary method, requires a good balance and a careful experimenter, but Sonstadt's solution enables us to separate from each other, as well as to distinguish, almost any two minerals differing in specific gravity, providing neither exceeds 3.

Sonstadt's solution is made by dissolving mercuric iodide and potassium iodide alternately in a saturated solution of the latter salt, until the liquid refuses to dissolve any more of either. A little powdered potassium iodide and a few drops of mercury are then added, the mixture shaken, and, after some hours' rest, filtered

* In these the ordinary ray is always more refracted than the extraordinary.

if not clear. The sp. gr. of such a solution slightly exceeds 3. I find it convenient to prepare two other strengths of Sonstadt's solution.

A. sp. gr. about 2.63.
B. „ „ 2.67.

In solution A minerals lighter than quartz, such as the felspars, float; solution B serves to separate beryl, which sinks therein, from quartz; while in the saturated solution, C, all the minerals heavier than beryl sink.

Before giving special illustrations of the results obtained by the use of Sonstadt's solution, permit me to draw your attention to the claims of two recent writers as to the origination of this method of separating minerals differing in specific gravity. In the "Comptes Rendus" for the 18th February, 1878, we have a M. Thoulet recommending a solution of iodide of mercury in iodide of potassium, for the separation of the non-ferruginous minerals of rocks, provided their sp. gr. lie between 2.2 and 3. But M. Thoulet would seem to be perfectly ignorant of all that has been done by Sonstadt and myself working in this direction. He does not even know how to prepare the solution properly, for his greatest density is but 2.77 at 11° C. He clearly is ignorant that Sonstadt pointed out the solubility of K I in the solution having that density, nor the further solubility of $Hg\ I_2$ in the liquid thus obtained. But if it takes four years for a method to reach France, there is no excuse for Mr. E. T. Hardman, F.C.S., of the Geological Survey of Ireland. announcing, as a discovery of his own, the applicability of Sonstadt's solution, as I have named it, to the separation of mixtures of minerals. I have used it for years for that purpose, a purpose flowing out of Sonstadt's original statements and suggestions.

Mr. Hardman says that he does not gather from my paper that the solution has been "practically used for analytical purposes." In the paper of mine, from which he quotes,* I state—"A few repetitions of this process seldom fail in effecting such a separation in an hour, as would have taken days, or have been impossible by the ordinary method of mechanical selection." If this statement does not involve the experimental application of Sonstadt's solution to analytical purposes, I am at a loss to know what words should be used to convey the meaning intended. Chemists are not in the

* "Minarological Magazine," Nov., 1877.

habit of laboriously separating powdered or crushed mixtures of minerals into their constituent species, except for the purposes of analysis.

I have before me two different strengths of Sonstadt's solution. This one, which we will call C, has the sp. gr. 3, the other, B, is about 2.67—the latter we will use for our experiments. First of all, let us introduce a piece of pure rock crystal—this just floats; so does a bit of yellow cairngorm. An amethyst sinks, a dark one very decidedly. Beryl sinks more distinctly still, while topaz and sapphire sink like lead, not only in this solution, but also in solution C. In the case of a parti-coloured amethyst crystal—one end dark and the other light-coloured, the dark end will be the lower. Opals are quite buoyant in solution B, and even milky quartz, which contains a few per cents. of opal, and has the sp. gr. of about 2.64, floats easily. Here are a few specific gravities of varieties of quartz :—

Milky	2.642.
Pure Rock Crystal	2.650.
Brown Cairngorm...	2.656.
Amethyst	2.659.
Very dark ditto	2.662.

A very instructive experiment consists in heating the solution in which are a number of minerals just floating, just suspended or just sunk. The coefficients of expansion of the liquid and of the several minerals being different, the alterations of position which occur are very striking.

The study of our diagrams of sp. gr. afford materials for other experiments with Sonstadt's solution in addition to those I have named. Solution C. often also enables us to distinguish between minerals which may be easily confused together, such as nephrite and jadeite, or euclase and triphane.

Leaving Sonstadt's solution, let us consider for a few minutes some improvements in the ordinary method of taking specific gravities by weighing the substance in air and then in water. If we attempt such determinations with a delicate balance, we shall find an insuperable difficulty in the viscosity of the water. Long before the sensibility of the balance is exhausted, the oscillations of the beam cease. By substituting alcohol of such a strength that it has no tendency to absorb water or lose spirit, this difficulty may be overcome, the sp. gr. of a large supply of this alcohol at

various temperatures ranging between 10° and 20° C; these determinations are made in Sprengel's apparatus. The pan of the balance for holding the mineral is of German silver; it is suspended from an upper pan (for holding the counterpoise necessary on the immersion of the lower pan) by a single fibre of strong unspun silk; one such thread has been in use for four years in my laboratory. The balance I have employed is one of Oertling's finest assay balances. The sp. gr. of fragments weighing up to about 2 grams. may be taken. The balance will distinctly show the 40th part of 1 milligram; the errors of the specific gravities lie probably within 0.005.

Speaking of specific gravities I am reminded of a plan of getting rid of adherent air by means of CO_2 and a faintly alkaline liquid.

When a solid or a powder is not easily wetted by water, we may first surround it with pure carbonic acid gas, then absorb that compound by means of a very dilute solution of caustic soda. Pure water may then be gradually substituted for the alkaline liquid, and the determination of the sp. gr. completed by weighing in the usual manner.

Professor Church concluded his paper by some references to the value of the dichroiscope, and of Sonstadt's solution in the microscopic study of rocks: he also referred to various public collections of precious stones. The well-arranged series of the British Museum and the Jermyn-street Museum were named, but particular attention was directed to the Townshend jewels in the South Kensington Museum. He pointed out, in detail, the numerous and absurd mistakes in the authorized catalogue of that collection —mistakes repeated in successive editions, although attention had been drawn to them in 1871 in "The Spectator," and "The Quarterly Journal of Science." All the corrections then made were afterwards (1874) adopted by Mr. Hodder M. Westropp in his revised list of the Townshend Collection.

EXCURSION TO THE CRYSTAL PALACE.

APRIL 6TH, 1878.

Director.—Professor J. MORRIS, F.G.S., &c.

This excursion was intended to afford Members an opportunity of inspecting those objects of geological interest which have been placed in the Palace and grounds for educational purposes.

Commencing with the interior of the building, the Director pointed out the specimens of fuel, such as peat, lignite, and various kinds of coal—the bitumenous, cannel, and anthracite—and explained the origin and special uses of each. Many of the products of carbonaceous substances and of the distillation of carbon compounds were also brought under notice. Collections of flint implements, both of pre-historic and of recent age, next claimed the attention of Members, and subsequently sections showing the geological structure of the London Tertiary Basin.

Passing out into the grounds, the party proceeded to the large and very accurate model of a coal-field, near the lake, showing the position of the coal seams and the dip of the various strata of sandstones, limestones, grits, clays, and shales—the rocks themselves having been brought from Carboniferous formations in Yorkshire and Derbyshire. In the Carboniferous Limestone there are fissures filled with spar and mineral veins, and one of the fissures opens into a cavern, so characteristic of this formation. The Devonian is also seen underlying the Carboniferous Series, and above them are beds of the Permian horizontal, and, therefore, unconformable to those below, which all incline to the north. Illustrations of faults are also given.

The lake was next visited, where illustrations are given of cliffs, shores, and islands; and inhabiting these are life-size models of various forms of extinct animals, beginning with the Labyrinthodon and Dicynodon of the Permian and Trias; the Ichthyosaurus, Plesiosaurus, and Teleosaurus of the Lias; the Megalosaurus of the Oolite; the Iguanodons and Hyalosaurus of the Wealden; and the Mososaurus and Pterodactyles of the Cretaceous period. There are also to be seen models of some of the extinct Mammalia of the Tertiary period—*Palæotherium*, *Anoplotherium commune*, and *A. gracile*—and of the Post-Tertiary, *Megatherium*, *Cervus* and *Megaceros Hibernicus*.

These restorations, which are well executed, were done under the superintendence of Professor Owen and Mr. Waterhouse Hawkins.

EXCURSION TO CHIPPING NORTON.

APRIL 22ND AND FOLLOWING DAY.

Directors—THOMAS BEESLEY, Esq., F.C.S., and W. H. HUDLESTON, Esq., M.A., F.G.S.

(*Report by* MR. HUDLESTON.)

The chief object of this Excursion was to inspect that portion of the new railway, intended to connect Banbury with Cheltenham, which lies betwixt Chipping Norton and Hook Norton—a length of about five miles. As Mr. Beesley had read a Paper before the Association in June, 1877, dealing with the geology of the railway wherein the sections were described and full lists of the fossils appended, considerable interest was felt in the matter, and the Members, with his valuable Paper in their hands, were well instructed beforehand in the work cut out for them. The Association having visited Banbury so recently as 1873, also under the guidance of Mr. Beesley, it was considered that the neighbourhood of Chipping Norton would afford the greatest amount of novelty, and that town accordingly was selected for the rendezvous.

Early in the afternoon of Easter Monday the party from London, conducted by Dr. Foulerton, the Honorary Secretary, met the two Directors at the Chipping Norton Railway Station, which lies at the foot of the terrible hill on which the town is built. Their numbers were swelled by a reinforcement of the local geologists, amongst whom were Mr. Walford, of Banbury, and Mr. Windoes, of Chipping Norton, whose collections, together with that of Mr. Beesley, have thrown so much light on the palæontology of the district.

An unfinished tunnel, intended to pass through a spur of the massive hill, on the upper slopes of which the town of Chipping Norton is built, was the first object noted along the new line. The waste heaps of clay around the shafts attracted the attention of Members as the party ascended from the low ground, and several good fossils—chiefly from the *Am. capricornus* and *Am. margaritatus* beds—were secured. The quantity of *Cypricardia intermedia* is noteworthy: the shells sometimes come out of the rock in the most perfect condition, like a nut out of a husk, and great numbers of them were secured by the early collectors. Mr. Beesley's list* of the

* "Proceedings of the Geologists' Association," Vol. v., p. 182.

fossils from the above zones attests the richness of the Middle Lias in this locality, and the care with which it has been worked.

The Sections leading up to the tunnel were partly grassed over, and the sequence from the *capricornus* clays through the *margaritatus* and *spinatus*-beds into the blue clays of the Upper Lias and thence into a rubble of *Clypeus*-grit was not very clear. The Upper Lias is said to have a thickness of some 35 feet hereabouts.

There is a commanding view from the top of the hill overlying the tunnel, especially in a north-westerly direction, over the Oolitic outliers of the Cotteswolds, and here Mr. Beesley gave some account of the physiography of the district through which the line is carried in the direction of Hook Norton. On the northern horizon is the Bright Hill famous for the Rollwright Stones, concerning whose origin archæologists generally have much to say. The ridge on which they stand is interesting as forming, in this region, the watershed between the Thames and Severn basins; and the stones have this peculiarity, that those who count them never arrive at the same conclusion as to their number. The same spell which rules the Rollwright Stones has cast its glamour more or less over the geology of the district, especially as regards the great and variable series of beds which overlie the Lias.

A walk of a mile or so along the line brought the party to the cutting at Langton Bridge, where one of the most interesting sections afforded by the new railway is displayed. It will readily be understood by those who take an interest in Oolitic geology that the region, where the S.W. or Cotteswold type of Lower Oolites passes into the N.E. or Northamptonshire type, is one worthy of close attention. Probably no better section for showing the junction between the Inferior Oolite (Bajocian) and Great Oolite (Bathonian) has hitherto been exposed in North Oxfordshire than this one at Langton Bridge. Yet owing to the high angle at which the beds dip towards the N.E. and the consequent tendency to slip, together with other causes, the sequence is by no means easy to read, and is fruitful of divergent opinion; the Rollwright glamour reigns in the valley as well as on the hill.

Unfortunately this is just one of those places where one misses seeing a great deal. Probably about 20 feet of Inferior Oolite beds are exposed, but no *Clypeus*-grit, if indeed the real *Clypeus*-grit extends as far, but any how the base is not visible, as the cutting does not extend down to the Upper Lias. The character of the Inferior Oolite is most changeable and deceptive, but is

typical of that which exists in this immediate district on both sides of the great fault, and may be described as consisting of pale fawn-coloured gritty limestones, partly oolitic, with variable proportions of sand and iron, which produce the most chameleon-like effects within short distances, and lend themselves readily to those who are disposed to doubt the identity of anything. Casts of univalves have been noted, and a full-sized *Holectypus depressus* was found, but it may be said with truth that recognisable fossils are very rare. This sort of Inferior Oolite is, in part, the 5'g7' of the Geological Survey (Sheet 45, N.W.), and perhaps it might be best known by that designation only. It certainly must occupy a very high position in the series, being always above the *Clypeus*-grit, where that phase of the Inferior Oolite obtains; and we shall see presently that the *Clypeus*-grit of Chipping Norton is well within the *Parkinsoni*-zone. In the district round Chipping Norton, extending probably as far as Langton Bridge, therefore, the lower zones of the Inferior Oolite are absent, and the term "Northampton Sand," as applied to such beds, seems inappropriate—the real Northampton Sand being confined to the zones of *A. Murchisonæ* and *A. opalinus*.*

Avoiding all stratigraphical, and, as much as possible, all minor details, the following is a summarised section; the thicknesses, &c., would vary within short distances:—

LANGTON BRIDGE (Line 550 feet above sea level).

		FT.	FT.
A	Limestones (sometimes flaggy) and grey Marls—*Ost. Sowerbii* and *Rhynch. concinna*	50	
	Flaggy Limestones	11	
	Rubbly Limestones and Marly Clays, with *Cypricardia* (small), *Ostrea Sowerbii*, *Rhynch. concinna*, varieties of *Terebratula*, and large *Clypeus*	4	
	Limestones with *Rhynchonella* in the upper bed ...	4	69
B	Grey Marl with *Ost. Sowerbii*	2	
	Black Clay with ochreous shelly lumps, apparently fragments of oysters	3	
	Sticky marly Clay with small *Ostrea*, &c.	2	7
	Loose red sand, in places, derived from the decomposition of—		
C	Inferior Oolite Limestone, previously described, base not seen...		20

* Sharp, "Oolites of Northamptonshire"—Quar. Journ. Geol. Soc., Vol. xxix, p. 285.

Whatever names may be given by geologists to the peculiar argillaceous series, B, its total contrast to the sandy limestones of the Inferior Oolite is complete, and it seems to constitute a fitting introduction to the thoroughly Bathonian group of beds which succeed. Those who derive their impressions from Northamptonshire may fancy they see in it the equivalent of the Upper Estuarine, but they should at least remember that in this section 70 feet of Marls and Limestones belonging to the Lower division of the Great Oolite (Bathonian) succeed, being doubtless the equivalents in a great measure of the Stonesfield Slate. It must not be forgotten on the other hand what an enormous thickness of partly argillaceous beds, known as Fullers Earth, are interposed in the S.W., between the Great and Inferior Oolites—beds which are 150 feet thick at Bath, 70 feet thick at Minchinhampton, and yet are reported as having entirely disappeared some twelve miles short of this spot. Avoiding for the present the subject of correlation and nomenclature, we see here two extensive groups of limestone, the lower one for the most part gritty and unfossiliferous, of a pale fawn colour; the upper one grey, argillaceous, and full of beds crammed with *Ostrea*, *Rhynchonella*, &c. They are divided by a peculiar black clay, which seems almost unconformable to the underlying beds.

On emerging from the cutting the whole series is lost sight of, and the line crosses the bottom of the valley to the other side of Rollwright Ford (Limekiln Farm): thus the continuity of the section is broken, and when resumed much higher beds are reached.

This further portion of the line being reserved for the following day, the party took to the road, where they inspected a very fossiliferous quarry in the Bathonian series, having a strong northerly dip, remarkable for the abundance and size of *Terebratula maxillata*—a bed, in fact, like the one so well known at Enslow Bridge. This Mr. Beesley considers to represent the junction of the typical Great Oolite with the lower zone. A walk through the picturesque village of Over Norton to the town of Chipping Norton completed the day's work, the party putting up at the White Hart. In the evening Mr. Windoes exhibited a portion of his collection.

On the following day a slight deviation from the programme was made, in order to inspect some quarries in the immediate vicinity

of the town, which, it was thought, might throw some light upon the sections disclosed along the railway.

Notwithstanding the ample illustration which the Oolitic geology of Oxfordshire has received at the hands of numerous writers, the immediate neighbourhood of Chipping Norton has been wonderfully neglected. Prof. Judd* observes that "as we pass northwards and westwards into Oxfordshire the Ragstone division of the Inferior Oolite no longer presents its well-marked subdivisions, but, as shown by Mr. Hull, is represented only by the *Clypeus*-grit, which, becoming more and more reduced in thickness, finally disappears near Chipping Norton." From Professor Hull† we learn that the *Clypeus*-grit is a rubbly white oolite occurring at the top of the Inferior Oolite immediately below the Fuller's Earth. It makes its appearance within two or three miles E. and S. of Leckhampton Hill, and is characterised by many fossils of the Ragstone. Near the banks of the Windrush, some ten miles S. W. of Chipping Norton, "about 15 feet of rock is exhibited, of an exceedingly coarse-grained oolite, in which were noticed *Clypeus Plotii*, *Terebratula globata*, and *Lima gibbosa*. It is capped by the shelly freestone of the Great Oolite, without the intervention of the Fuller's Earth, which has altogether disappeared." Eight miles near Chipping Norton we again‡ hear of this *Clypeus*-grit at Churchill, "where there are several quarries in which the rock is very fossiliferous." The usual fossils are quoted along with *A. Murchisonæ*—evidently an error. The outcrop of the Inferior Oolite thence continues northwards, "and winds round by Chipping Norton till it abuts against a fault near Coll's Combe Barn."§

This part of the story is intelligible enough, but when we turn to the Geological Survey Map, Sheet 45, it will be remarked that in the N.W. quarter-sheet, this narrow band of *Clypeus*-grit is represented as overlaid by the extensive formation, 5′g7′, described in the margin as "Northampton Sand (Sands, calc sandstones, Ironstones, and Limestones), Lower Zone of Great Oolite=Inferior Oolite"—clearly an intimation that the division between Bathonian and Bajocian is not very easy to trace hereabouts. On

* "Introductory Essay to the Geology of Rutland," p. 11.
† "Geology of Cheltenham," p. 46, *et seq.*
‡ Hull—"Country about Woodstock" (Sheet 45, S.W.), p. 13.
§ Green, in Memoir to Sheet 45, p. 9.
|| *Loc. cit.* p. 30.

this point Professor Judd‖ observes—"It has been found impracticable in this district to draw a line of boundary between the representatives of the Great and Inferior Oolite. Thus it has arisen that under the term "Northampton Sand" are included, in North Oxfordshire, the whole mass of variable sandy strata (passing at some points into imperfect ironstones, and at others into impure limestones), which intervene between the Upper Lias Clay and the marly limestones of the Upper Zone of the Great Oolite."

Such an essentially provisional arrangement may suit in some places, but at Chipping Norton it is certainly liable to mislead, as we have the conventional namesake of the true Northampton Sand, which at Northampton comprises the zones of *A. Murchisonæ* and *A. opalinus**, superposed on the *Clypeus*-grit, or *A. Parkinsoni* zone—in other words, the Inferior Oolite is turned upside down.

To ascertain, if possible, how far these matters are capable of further elucidation, was one of the objects of the Excursion to Chipping Norton, but as some of the points were not entered in the original programme, the party during the earlier hours of the second day became divided. Instead, therefore, of giving the experiences of each portion separately, a brief summary of the whole is substituted.

The town is situated towards the top of the western slope of a great massive hill of Jurassic rocks, separated from the main range of the Cotteswolds by the vale of Moreton. A "bench mark" on the Three Tuns inn, near the north end of the main street is 658 feet above sea level, and this may be taken as the general level of the principal part of the town, the summit of the plateau above, on the Banbury road, attaining an altitude of about 740 feet. Like so many other places, its position has been determined by a copious spring, which issues from the hill side at the junction of the Upper Lias Clay with the Inferior Oolite (*Clypeus*-grit). The position of this spring is about 20 feet immediately below the afore-mentioned Three Tuns in that part of the town known as "Tite End."†

From this point to the *Cetiosaurus* quarry at the top of the hill, in a direction nearly due E., is a rise of between 70 and 80 feet. The *Clypeus*-grit forms the lower part of this rise, and that

* See *ante* page 380.

† "Tite" is an obsolete word used chiefly in Oxfordshire, and, according to Halliwell, signifies springs of water.—Kirtland, "Early History of Chipping Norton."

portion of 5′g7′, which we may term the Chipping Norton Limestone, constitutes the rest, making no allowance for dip. Fortunately a well, nearly on a level with the quarry, supplies us with the means of checking these measurements. It is 55 feet deep, so that we shall not be far wrong in assigning 60 feet as the thickness of the beds which lie between the Upper Lias and the band of Blue Clay in the *Cetiosaurus* quarry, presently to be mentioned. During the visit of the Association there was no exposure of the *Clypeus*-grit, nor any means of noting its junction with the overlying beds. The following are some of the fossils Mr. Windoes has obtained from it :—*Ammonites Parkinsoni*, *Homomya gibbosa*, *Pholadomya Heraulti*, *Ph. Dewalquei*, *Cardium citrinoidum*, *C. lævigatum*, *Trigonia costata*, *T. signata*, *Lima duplicata*, *Pecten*, several small forms, *Terebratula globata*, *Terebratula* sp., *Rhynchonella concinna*, *R. angulata*, *Holectypus depressus*, *Clypeus Plottii*, *Anabacia orbulites*, *An. hemisphærica*, *Montlivaltia trochoides*, and one or two fossils which may be new. This group of fossils points to a very high part of the Inferior Oolite, almost to the *Pholadomya*-grit of Dr. Lycett.

The overlying limestone must, therefore, be very high indeed. Few fossils have been obtained from it at Chipping Norton, there being no exposures of the lower beds, which, almost alone, appear fossiliferous. In the neighbourhood of the Priory Farm, however, rather over a mile E.N.E. of the *Cetiosaurus*-quarry, the sandy limestone which there overlies the *Clypeus*-grit has yielded abundance of *Trigonia signata*, together with a very variable Oyster, and the same *Trigonia* may be found at one or two other quarries. The form of the shell differs somewhat from the one in the *Perna*-bed at Cold Comfort (Cheltenham).

Reverting now to the *Cetiosaurus*-quarry, particular attention was paid to this section. The surface is about 715 feet above sea level, and is believed to be about 60 feet above the Upper Lias immediately beneath it; the quarry has a face of some 20 feet.

CETIOSAURUS QUARRY, CHIPPING NORTON.

		FT.
A	Oolitic limestone, denser than the lower series (C), with *Ostrea*, *Pecten*, &c. Just a fragment at the top of the section	1 — 3
B	The argillaceous series: the upper part sometimes a grey marl, with *Ost. Sowerbii*, the middle a dense blue clay, shaly in places, with bones of *Cetiosaurus*; the base variable	about 3

		FT.
	Variable line of loose reddish sand.	
C	Oolitic limestone of a different character to A: rolled spines of *Acrosalenia*, fish teeth. &c., but poor in fossils. The top beds of the Chipping Norton Limestone	1

Here there is a definite line and a thorough physical break, and this may be of use ultimately in fixing the boundaries of the Inferior and Great Oolite. In the Argillaceous Series, B, we may have the representative of the Black Clay of Langton Bridge, about two miles distant. The irregular abundance of grey marl, with *Ost. Sowerbii* above the Clay, favours the view, but as nearly the whole of the Upper Limestone series, A, has been removed at the *Cetiosaurus*-quarry, the section is incomplete in this direction. It is probable that in C of this quarry we have rather higher beds than in C at Langton Bridge, the argillaceous series being transgressive over different beds of the Inferior Oolite.

About a mile from the turnpike on the high road due south of Chipping Norton are two quarries, which seem to afford a further clue. A section, constructed from the two combined, shows the following sequence:—

QUARRIES ON CHADLINGTON DOWN.

South Quarry—

		FT.
A	Beds of limestone with *Cardium Stricklandi*, *Lima cardiiformis*, *Ostrea Sowerbii*, *Rhynch. concinna*, &c., down to a water line (well)	22

North Quarry—

		FT.
B	Limestone rubble and marl, with a few *Ostrea Sowerbii*, Band of Blue Clay. Lower marly rubble, with small univalves, jaws of *Cidaris*, spines of *Acrosalenia*, plates of Starfish, &c.—say	3
C	False bedded flaggy oolites, with few fossils to floor of quarry—say	7

Thus at three different points, viz., at Langton Bridge, at Chipping Norton, and on Chadlington Down, we have two calcareous systems separated by a peculiar belt of Clay and Marl. It may be doubted whether this dividing Clay can be exactly referred either to the Upper Estuarine or to the Fuller's Earth. The beds of this region have a type of their own, and it is no use

trying to force them into the ready-made clothes of other districts.

Reverting now to the new line, towards noon the bulk of the party proceeded to the Limekiln Farm, where the railway was left on the previous evening, and in so doing, descended the steep hill into this curiously faulted valley. At the Cross roads (surface of road 686 feet, according to Mr. Parker's determination) there is a cutting in the so-called *Clypeus*-grit, where, according to Mr. Windoes, the fossils of this horizon occur, but the matrix is not rubbly, the lithology being more that of the sandy and occasionally ferruginous limestone. The blue clay on which they rest is marked in the map as Upper Lias, and this is exposed further down the hill, but is without visible fossils. After vain attempts to find anything, Mr. Beesley started the theory that it was not Upper Lias at all, but one of the Estuarine Beds. This idea took immensely, but being now within the full influence of the Rollwright glamour, the primary schism immediately sub-divided itself, one party of heretics contending for the Blue Clay of the Langton Bridge Section, and another for the Clays of the Forest Marble, so well seen at the Pest House Cutting. The matter was not settled at the time, but subsequent investigation has shown that the Surveyor was perfectly right in mapping it as Upper Lias.*

Whilst the Langton Bridge Cutting, visited on the previous evening, displays the Lower Zone of the Great Oolite resting upon the Inferior Oolite, the sections east of the Limekiln Farm seem wholly in the Upper Division of the Great Oolite. The portion exposed commences with creamy limestones, containing corals, remains of fish and saurians, and a tolerable abundance of other fossils. The base of the Upper Division of the Great Oolite is hardly seen, but the sequence upwards is complete, and is perhaps the most interesting portion of the whole line. Above the creamy limestones is another argillaceous series, then some limestone bands overlain by a mass of blue marly shale, the whole being capped by a thin and rather poor representative of the Cornbrash. One of the limestone bands, west of the Pest House Bridge, known as the *angulata*-bed from the abundance of that species of *Astarte*, is a complete museum, many of the fossils

* Mr. Walford found foraminifera, spines of urchins, &c., not unlike those of the Upper Lias of Chipping Norton; and Mr. Parker actually found the Marlstone beneath the Blue Clay, just as indicated on the map.

being characteristic of the Forest Marble of South Oxfordshire, &c. *Nerinæa Royssii*, *Eucyclus nodosus*, *Phasianella variata*, *Pteroperna costatula*, *Gervillia Waltoni* (local variety), *Cardium Stricklandi*, *Cypricardia rostrata*, *C. nuculiformis*, *Corbula Hulliana*, and *C. striata* may be noted. For fuller list consult Beesley.* This section corresponds fairly with the classic one at Kirklington,† and although the Geological Survey differed from the late Professor Phillips as to fixing the line between the Forest Marble and the Great Oolite Limestone, this by no means affects the general similarity of the sequence.

The line attains its highest position, in a geological sense, with the Cornbrash of the Pest House Cutting; eastwards of this for some distance are small excavations at intervals disclosing portions of the Forest Marble series,‡ sometimes crammed with oysters. Further east, again, is a bed of Great Oolite Limestone, which afforded some good pickings; a band of coral (*Thamnastræa Lyellii* principally) occurs in it.

A short embankment and wooden viaduct lead to a cutting at Duckpool Farm on the south side of Hook Norton Hill, where there is an interesting and much debated section exposing the northern bounding fault of this longitudinal patch of Bathonian rocks.§ In spite, however, of the stratigraphical interest attaching to a fault, Oolitic geologists would willingly have dispensed with a phenomenon which conceals the junction between the Inferior Oolite and the Great Oolite, and thus prevents the instituting of a proper comparison with the section at Langton Bridge. The difficulty of interpretation is further increased by a small subordinate fault on the south side, and also by the slipping of the beds so as to conceal the probable hade of the main fault. What we really have, then, is the Upper Lias sur-

* "Proceedings Geologists' Association," Vol. v., p. 165.

† Hull. "Country Round Woodstock" (Sheet 45 S.W.), p. 20.

‡ In Northamptonshire and Rutland what are called the Clays of the Great Oolite represent to a certain extent this group.

§ These marked stratigraphical features long ago attracted the attention of Conybeare and Philips, who observe that "in the valley between Swerford and Great Rollwright the Oolite beds are thrown down by a considerable subsidence, pitching in a steep angle towards its bottom, which they cross close to the entrance of Swerford Park, and lying there as in a hollow trough, again rise towards Great Rollwright." "Geology of England and Wales," p. 221.

mounted by the Inferior Oolite (Hook Norton type) on the north faulted against a variable mass of Bathonian rocks, consisting of Marls with *Ostrea Sowerbii* and bands of hard stone in places, succeeded by a belt of greenish or olive-coloured sands and clays, and the whole surmounted by a fragmentary line of limestone with *Nerinæa*, &c., probably representing the base of the Great Oolite Limestone (Upper Division). With the exception of this thin cap of limestone, the whole of the beds on the south side of the fault, about 15 feet thick, may be referred to the Lower Division of the Great Oolite system. At present, therefore, the section is so far incomplete that we cannot feel sure of seeing the top of the Inferior Oolite on the north side of the fault, nor yet the base of the Lower Division of the Great Oolite on the south. Should the Lower Division of the Great Oolite system be as thick here as at Langton Bridge (70-80 feet), the amount of throw must be very considerable.

The thickness of the Upper Lias at Hook Norton is estimated by Mr. Beesley at from 30 to 40 feet with *Ammonites bifrons*, *communis*, *fibulatus*, and *opalinus*, and above this come the sandy thick-bedded limestones of the Inferior Oolite belonging to a different zone to that at Langton Bridge, and containing a very respectable number of fossils (see Mr. Beesley's list, *loc. cit.*). The hill is not pierced, but there are two extensive cuttings on either side. The one on the north shows a deep section, which is quickly exchanged for an equally lofty embankment, where the line debouches upon the broad Hook Norton valley, which it is proposed to cross on one of the most ambitious viaducts ever projected by engineers. The embankment is composed largely of Inferior Oolite masses, which have yielded some good pickings. Mr. Beesley considers that the Inferior Oolite of Hook Norton is in the *Murchisonæ*-zone; but as the term *Murchisonæ* is applied to so many ammonites, it is generic rather than specific in its application. The characteristic ammonite here is not by any means the *A. corrugatus* of the *Murchisonæ*-zone of Cheltenham, but a very discoidal ammonite, one of the smooth and compressed forms which might go under the general designation of *læviusculus*.

The conditions which produced this sandy limestone seem to have been favourable to *Trigoniæ*, as several species are quoted from

here. A very remarkable group of the *Undulatæ*, which may be referred generally to the *T. producta* of Lycett,* but which also has affinities with *T. literata*, Y. & B., and with *T. V.-costata*, Lyc., is another proof how local are the forms of this genus—so abundant in the shallow waters of the Jurassic period—and how difficult it is to find names for them all.

At the village of Hook Norton the party began to separate, the major portion returning directly to Chipping Norton, whence, after a hurried dinner, most of them went back to London in the evening.

On the Lancashire Coal-Fields.

By C. E. De Rance, Esq., Assoc. Inst. C.E., F.G.S., of the Geological Survey of England and Wales.

(Read February 1st, 1878).

At the close of the Carboniferous period the British Isles, in common with the neighbouring parts of Europe, were subjected to great lateral pressure, acting in a general N. and S. direction, which produced considerable terrestrial movements in the earth's crust, causing the strata to be thrown into a series of flexures, ranging in a direction at right angles to that of the pressure exerted. In France, Belgium, the South of England, and in Yorkshire, the direction of the axes of these flexures is nearly E. and W.; in Lancashire, in the hills of the Pendle range E.N.E. (E. 35 N.).

One of the greatest of these rolls or anticlinal axes now traverses the Yoredale Rocks and Millstone Grit separating the Lancashire and Yorkshire Coal-fields from that of Durham. These anticlinal arches, more or less traversed by fissures, were readily attacked by denudation, and it is due to this cause that anticlinals are found along the lines of valleys, while synclinals occur in hills forming lines of strength. It was by this denudation, at the close of the Carboniferous Epoch, that so large an area of Coal Measures were swept away.

* Monograph of British *Trigoniæ*, in Pal. Soc., p. 60.

WEST FYLDE AND BOLLAND.

1. Clitheroe and Skipton Anticlinal. (Longridge Fell, Fell synclinal.)	Roach Bridge—Darwen—Ribble—To Bolton Abbey, 35 miles.
2. Slaidburn Anticlinal	Lond Valley—Chipping—Whitewell.
3. Sykes „	Fylde or Brack—Fells of Bowland.

Mountain Limestone.—The base is seen resting on Silurian Rocks in the valley of the Ribble north of Settle, near Malham Farm. At Clitheroe the Wotton beds are not brought to-day by the anticlinal, and the thickness without these is no less than 3,250 feet.

The limestones of the Forest of Pendle are of great value for their lime-producing qualities, both the lower black bituminous varieties and the upper grey beds, the former being the most desired when whiteness is an object, the whole of the colour being expelled by burning.

Shales with Limestone.—These series consist of an alternation of shales, thin limestone, cement stone, and thin ironstones, giving ries to springs containing sulphuretted hydrogen gas; one of these occurs at Clitheroe, and has a bath-house attached. The thickness of this series is not less than 3,225 feet.*

Lower Yoredale Grit.—This bed resembles the Gannister beds of the Coal Measures in appearance and hardness, is often absent, but when present it invariably forms the base of the Bowland Shales, so named by Professor Phillips, and plays an important part in the scenery of the Forest of Pendle, the steep slopes of which are all composed of the disintegrating shales of this age, reaching a maximum thickness of 700 feet. The commonest fossil is *Posidonomya Gibsoni;* Goniatites and Fish remains occur, as well as seams of ironstone, which give the shales an appearance of Coal Measure, which have led to many fruitless borings.

Upper Yoredale Grit is well seen in the quarries at Longridge Fell, near Preston, which are very extensive, the grit reaching a thickness of not less than 1,000 to 1,200 feet. Overlying

* To render this paper useful to those who may wish to traverse the district, I have largely quoted thicknesses and other details from the Memoirs of the Geological Survey, especially the work done by Mr. Tiddeman, and have also laid Mr. Binney's in the Transactions of the Manchester Geological Society, and Prof. Hull's papers in the Quarterly Journal of the Geological Society, under contribution.

the Upper Yoredale Grit, which contains impressions of plants, occurs a bed of shale 200 feet in thickness, on which rests the Kinderscout Grit, forming the base of the Millstone Grit series, which is divided into four great divisions by three thick beds of shale, and these beds are often again subdivided by intercalated shales often of considerable thickness. These subdivisions, though useful for purposes of identification in Derbyshire, Lancashire, and South-Western Yorkshire, are local and mere divisions of convenience, the whole of the Millstone Grit, physically and biologically, forming one formation.

The Kinderscout or Fourth Grit is well seen in the mass of elevated moorland country raised by faults, between the Wigan and Burnley Coal-fields, especially at the western edge at Withnell Moor, where it has been bored into in a fruitless search for coal to a depth of nearly 1,000 feet, the Yoredale-shale being reached. The Grit here forms a peculiarly valuable building stone, which is largely quarried, underlying a conglomerate, formed of pebbles of white vein quartz. A fault traversing the quarry with an easterly down-throw, brings in the Yoredale-shale at the foot of the Fell to the west, which is cut off by a large fault, with a westerly down-throw, bringing in the Lower Coal Measures, containing workable coal-seams and fire-clays. The Kinderscout Grit, on the Moor above, contains numerous impressions of plants, chiefly *Stigmaria*, and some thin coal-seams, a few inches thick, testifying the proximity of land during the deposition of the strata.

The Sabden Valley Shales overlie the Kinderscout Grit, and in the country lying around the county boundary of Yorkshire and Lancashire, measured by Mr. Tiddeman, are 2,000 feet in thickness, and contain many wedge-shaped masses of Grit resembling the Kinderscout.

In the Ribble near Ribchester and at Roach Bridge, under the Permians of the Darwen, these shales contain ironstones with fossil *Goniatites*, *Posidonomya Gibsoni*, fish, and *Calamites*.

At Sales Wheel on the Ribble, thin limestones with Encrinites occur. Similar beds, with *Goniatites*, Encrinites and Brachiopoda, are described by Mr. Tiddeman on the top of the Kinderscout of Hole Brook, a tributary of the Darwen.

The Sabden shales at Shorebrook, lying below Noon Hill, east

of Rivington, contain numerous fossils, *Goniatites spiralis*, and two thin coal-seams.

The Third Grit overlying the shales is generally fine-grained, but occasionally forms a conglomerate, as at the fine cliff known as "the Ratchers," at Belmont, near Bolton. Sometimes the Grit is divided into two or more beds by thick shale, occasionally containing fossils, marine shells, and land plants.

The Shales lying at the base of the Haslingden Flags contain the "Brooks bottom," or Holcombe Brook series of Mr. Binney, containing two or three coal-seams associated with numerous plants, many of which occur in the shale overlying the Feather-edge Coal, and in the Lower Coal Measures, as do also the shells *Aviculopietee papyracea*, Sow, *Goniatites Listeri*, Mant., &c.

Beyrichia arcuata, Bean., *Spirorbis Carbonarius*, Murch., *Discina nitida*, Phill., also occur.

In the district south-east and east of Manchester, at Mottram, Brooksbottom, and Glossop, a coal from two to three feet in thickness occurs in this horizon, and is extensively worked under the name of the *Mottram* or *Simmondsly* Mine; everywhere that the seam is thick and valuable, the Feather-edge Coal, which should lie 60 to 70 yards above it, is either absent or very thin; whilst north of Rochdale, where the latter is thirty inches thick, and of good quality, the Mottram seam is valueless on Horwich Moor.

Haslingden Flags or Second Grit.—The shales lying between the first and third grit, over a considerable area, contain beds of fine grained micaceous flagstone and freestone, of great value for building purposes. On the surface of the flags annelide tracts, ripple marks, and rain drops may often be noticed, as well as carbonaceous partings.

The flags are generally divided by a thick bed of shale, the lower bed is largely quarried at Haslingden, the upper bed at Entwistle and Edgworth.

In the shale associated with these flags at Rivington, during the excavations connected with the Liverpool Waterworks, I noticed the black shales to be charged with fragmentary portions of *Calamites Suckowii*.

Rough Rock or First Grit.—The uppermost, or "first" bed of Grit is generally conglomeratic, hard, and coarse, but is sometimes

free from pebbles, and soft enough to be dug for sand; it is then, locally, called "Sand Rock," the thin coal occurring in it being termed the "Sand Rock Coal." Near Rochdale this coal-seam has a peculiar fracture, which has caused it to be named the "Feather-edge" coal,* the shales accompanying it yielded 18 species of fossils,† of which at least 9 (or 50 per cent.) occur in the overlying Lower Coal Measures. Of these 18 species, 13 are plants, and three shells of Marine Mollusca; amongst the former are *Calamites Suckowii*, *Pecopteris arborescens*, *Sigillaria hexagonia*, &c.; amongst the latter, *Aviculopecten papyracea*. Indications of this flora and fauna, with a few additional forms, occur at *three* intervals below this horizon, in the Millstone Grit Series:—(1) In a bed of shales in the second Grit; (2) in the bed of shales between the second and third Grits; and (3) in that between the third and fourth Grits. One can hardly resist the conclusion that a land-surface, on which these plants grew, must have existed throughout the whole of the Millstone Grit period, and down into the true Lower Coal Measures, and from which surface the plants migrated, as from time to time the shallow sea bottom, through the temporary stoppage of subsidence and subsequent deposit of sand, became land, more or less covered with freshwater, at the bottom of which, here and there, seams of coal from one inch to two feet in thickness were deposited.

The normal thickness of the Rough Rock is about 100 feet, but it often suddenly thickens, as from Blackburn to Hoghton Towers, where, as stated by Mr. Hull,‡ it expands from 100 to 450 feet in thickness. Supposing this expansion to have taken place at the base of the Rough Rock, or in other words, that it commenced to be formed in the area where it is thickest, before its deposition commenced where thinnest, it appears not improbable that the base of the Rough Rock where it reaches a maximum development may be synchronous with a portion of the Haslingden Flags, underlying the Rough

* Described by Mr. E. W. Binney, F.R.S., in "Trans. Geol. Soc. Man.," Vol. i.; by Professor Hull, F.R.S., in "Mem. Geol. Sur.," "Geology of Oldham," and in "Geology of Bolton-le-Moors."

† See List of Fossils by the late Mr. J. W. Salter, F.G.S., in "Memoir on Oldham."

‡ Mr. Hull "On Thickness of the Carboniferous Rocks of Pendle Range." Quart. Journ. Geol. Soc., p. 323. Professor E. Hull, F.R.S., gives the thickness of the Millstone Grit Series at Blackburn at 5,000 feet, at Burnley at 6,500 feet. Quart. Journ. Geol. Soc., August, 1868.

Rocks, where thinnest, especially as the Flags appear to be thin, or entirely absent, wherever the Rough Rock attains a maximum development. In fact, though the Millstone Grit as a *whole* maintains a general average thickness in any special area, its members in *detail* appear to be ever changing places in relative consequence with each other. Thinning out, intercalating, and wedging into one another, in a manner proving the shallowness of the sea, the existence of currents laden with different materials, and the proximity of land causing pebbles ever and anon to be rolled against the coast, which, when deposited, formed the conglomerates of the first and fourth Grits.

The Rough Rock is generally traversed by planes of current-bedding dipping W.S.W., and S.W., those found in the Kinderscout Grit also generally dip westward, proving that the currents, which caused the false bedding and brought the materials, in all probability, flowed from the east and north-east during the whole of the Millstone Grit period, or at least that part of it, when the land was below the sea-level. In many respects, there is a resemblance between the "Sands and Gravels," of the Glacial Middle Drift, and the Millstone Grits they so often overlie ; there is the same species of alternation of fine sandy with coarse sandy beds, the same occasional presence of conglomerates in the one, and of shingle beds in the other, in fact both sand and shingle is often so consolidated in the Lancashire "Middle Drift," by the infiltration of water, charged with carbonate of lime and iron, as to resemble the Kinderscout Grit so closely, as to make it difficult to tell a hand specimen of the one from the other. And there is the same phenomenon of excessive current-bedding, but the dip of the false-bedding in the Drift is to the E.S.E., or exactly in the opposite direction to that in the Millstone Grit. Thus the easterly extension of the Middle Drift, is cut off by the Penine Chain, and it is doubtfully synchronous with any deposit, in the low country, on the opposite side of the ridge, while the currents, which brought the materials of the Millstone Grit westerly, passed over what is now the Pennine Chain, for then of course the "Anticlinal Fault" had not come into existence.

Above the Rough Rock occur the Lower Coal Measures, or Gannister beds, consisting of a series of micaceous sandstone, evenly bedded, rippled and embrooked, often resembling those of

the Lower Keuper Sandstone shales, and thin beds of coal, locally known as "Mountain Mines," from their generally occurring in hilly situations.

The following gives the general sequence, &c.:—

BILLINGE DISTRICT.	FT.	IN.	HORWICH DISTRICT.	FT.	IN.
			Arley Mine.		
Middle Coal Measures ...	210		M. Coal M's. ...	858	
Lower Coal Measures Shales	850		L. Coal M's. ...	852	
Upper Mountain Mine...	2		= *40 Yards Mine*	1	4
Fire Clay and Shales... ...	10				
Fire Clay Coal		10	Measures	114	
Shales and "bullions" ...	245				
Bullion Coal		8	= *Upper Foot Mine.*		
Shales, Flags, &c.	46	1	Measures	36	
Gannister Coal	1	4	=*Gannister Coal.*		
Measures	181	8	Measures	36	
5th Coal	1	3½	=*Lower Foot Mine*	1	6
Measures	32.0				
Lower Mountain Mine	2.8	398	Lower Coal Measures	399	0
Lower Coal Measures	336.4				
Rough Rock	100		Rough Rock ...	126	1

From this table it will be seen that an accession of material occurs at the top of the Lower Coal Measures in the Horwich and Bolton section, the 210 feet of black shale, lying above the Upholland Flags of the Billinge column, being replaced by 858 feet of sandy flagstones, which in the district north of Heywood, occur underneath the Arley Mine itself, which forms the most natural base for the Middle Coal Measure series; a *physical break* is however sometimes seen between the black shales, and the underlying flagstones as the section near Bury, described by Professor Hull, where the Middle Coal Measures are unconformable, on the Lower Coal Measure, the latter having been distinctly denuded, the flagstone series having been reduced in thickness.

This physical break evidently represents a biological one; below it the Invertebrate fauna is characterised by the marine types *Goniatites*, *Aviculopecten* and *Lingula*, genera ranging upwards from the Mountain Limestone, and Yoredale Rocks, with many species in common, while in the Middle and Upper Coal Measures the majority of these species become extinct, and the Mollusca are confined to a few genera of bivalves resembling freshwater

mussels, with the one remarkable exception of the marine band discovered by Messrs. Green and Hull on the top of the Middle Coal Measures of Ashton Green.

The fossils were found in large concretions in shales, about 150 yards above the " Great Mine," of Ashton-under-Lyne, not the "great mine" which lies 33 yards above the *Black Mine*, the most valuable of the Oldham district, which occurs well down in the Middle Coal Measures.

Mr. Salter described the fauna of this band as comparable with that of the Shropshire Lower Coal Measures, yet wholly distinct, only one species occurring in common—*Aviculopecten papyraceus*, and this in a dwarfed condition, the usual Lower Cephalopod, *Goniatites* being replaced by *Nautili* and *Discites*. The *Nautilus præcox* of Salter has some affinities to Oolitic species. The most abundant shell was a new species of *Aviculopecten fibrillosus* of Salter.

To return to the Lower Coal Measures, it is worthy of note, that the shore-line conditions which brought about the conglomerates of the Millstone Grit, still existed at the time of the deposition of the " Woodhead Hill Rock," which occurs 70 or 80 feet above the base of the Lower Coal Measures, and forms the high ridges of Compton Moor, Bowstead, and Ogden Edges, and is a massive conglomerate, traversed by current bedding. This and the overlying Lower Coal Measures sandstones, as the Helpet Edge Rock, consist, like the Millstone Grit, of fragments of felspar, mica, and quartz, the detritus of granitic rocks. All these sandstones increase in thickness eastwards, and are more developed in Yorkshire than in Lancashire, and even west of the Pennine Chain, the change is very marked, thus the Helpet Edge Rock, between the 40 *yards Mine* and the *Bullion Mine*, is 130 feet in thickness, while at Billinge, west of Wigan, a few flags associated with 260 feet of shales alone represent the sandstone. In the latter section, overlying the Bullion Coal, occur 5 feet of black shales and bass, containing large nodules of argillaceous limestone, locally called " bullions," with *Goniatites* and *Aviculopecten*.

In the black shales forming the roof of most of the Mountain Mines, are generally *Anthracosia*, sometimes *Goniatites*, and more rarely *Aviculopecten*. The under-clay, especially of the *Gannister Coal*, is generally replaced by a peculiarly hard siliceous bed, locally

called "Gannister," full of roots of *Stigmaria.* In Horwich, west of Bolton, the Gannister is said to reach a thickness of no less than 35 feet, traversed by *Stigmaria.*

Beneath most of the coal-seams occur floors of white or grey soft unctuous clay, penetrated by roots and rootlets of *Stigmaria,* locally called "warrant," or "warren earth," above many of the coal-seams are trunks of *Sigillaria,* and *Lepidodendron,* especially above the Ince 4 feet coal, a fruitful source of accidents.

The Seven Feet or Rams Mine of Bolton and Clifton, is the equivalent of the Ince 7 feet coal, and at a short distance beneath it, occurred the erect fossil trees, discovered in the excavations for the Manchester and Bolton Railway, preserved by Mr. Hawkshaw, and now in the Owen's College Museum, Manchester, first described by Mr Bowman.*

The sections that have been drawn by the Geological Survey across the South Lancashire and Burnley Coal-fields and the surrounding tracts of older Carboniferous rocks well exhibit the series of flexures or foldings that the rocks of the Pendle Range have thrown by lateral pressure. These flexures traverse the country in a series of wave-like curves, the axes of which travel in an E.N.E. and W.S.W. direction, and form the Sykes, Slaidburn, and Clitheroe, and Rossendale Anticlinal of Messrs. Hull and Tiddeman.

The lines of geographical valleys range through the anticlines, as the valley of Sykes, Slaidburn, and Clitheroe, while the synclines occupy the fells and hills intervening.

The curve of the Rossendale Anticlinal, ranging through the ancient forest of that name and through Anglezark Moor, is low and gentle, and north and south of it lie respectively the Wigan and Burnley portion of the Lancashire Coal-field, which lie in basins, true synclinals of deposition, forming geographical valleys at the present time.

An examination of the thicknesses of the strata lying between the well-marked and well-known coal-seams of the Middle Coal Measures enables the relative rate of movement, as well as its position and duration, to be ascertained, which was the first expression of the continued subsidence that brought about those

* "Proceedings Geological Society," Vol. iii., p. 270.

flexures which separated the Lancashire Coal-field into distinct tracts.

With a view of endeavouring to ascertain what Lancashire coal-seams or groups of seams could be identified in the Flintshire Coal-field, I compared the various valuable sections published by the Geological Survey—those of Mr. Dickinson, in the "Transactions of the Manchester Geological Society," and others—and soon found that local thickening of measures evidently constantly took place, and considerable changes in the thickness and character of the seams themselves, but that the published sections were isolated as to be almost useless, as a means of discovering definite laws of thickening in a given direction, or for the identification of the thinner seams.

Towards this object I commenced collecting in 1868 the journals of all the sinking pits in the West Lancashire Coal-field I could obtain—which through the kindness of the Lancashire Colliery Managers, is now a very large number—and selecting ten of them, occurring as nearly as possible at equal distances from each other, along a line crossing the coal-field from S.W. to N.E., taking the Arley Mine—the lowest, but most valuable coal-seam of the Lancashire Coal-field as a geological datum—and plotting the section upward from it, Plate 61 of the Geological Survey, drawn by my colleague, Mr. Strahan, is the result.

For purposes of comparison, I have divided the Middle Coal Measures of the Wigan area into six groups :—

F.—*The Ince group;* from the Ince Yard coal to Pemberton 5 feet.

E.—*The Pemberton;* from the P. 5 feet to the Wigan 5 feet.

D.—*The Wigan;* from the W. 5 feet coal to the Wigan 9 feet.

C.—*The Cannel and King;* from the W. 9 feet to the Yard coal.

B.—*Bone coal group;* from the Yard coal to the Orrel 5 feet.

A.—*Orrel group;* from the Orrel 5 feet coal to the Orrel 4 feet at Arley Mine.

Commencing at the left hand, or S.W. end of the section, and following the groups towards the N.E., group A is seen to be

constant in thickness, the movement of subsidence that caused the lowering of the surfaces of plant-growth below the surface of the water to have been uniform in amount over a large area. A well marked horizon of fossil shells (*Anthracosia robusta*) at Wigan, which at St. Helen's is associated with a 6-inch coal, and the hard rag lying above this "cockle-shell bed," in the Wigan area is absent. At Pemberton the rag is of considerable thickness, and is known as the "Burr," or the "Scotchman."

Group B is thickest at St. Helen's (Column II.), the sediment between the Orrel 5 feet and the Whiston Main (or Roger-coal = Yard Mine) being at its maximum, and here we have the first indication of the special *axis of subsidence* which led to the formation of the Wigan basin, which axis gradually travelled north-eastwards in time until in the Ince Group A, it rested on Worthington north of Wigan. And it is especially worthy of note that the most remarkable phenomenon affecting any of the Wigan seams occurs at this very period, namely the local absence of the Pemberton 5 feet coal in special tracts, which I believe represent islands rising above the peaty tracts in which the coal was formed.

At Prestot the distance between the Arley Mine and the Ince Yard coal is 1,400 feet, while at Worthington, near Wigan, it reaches 2,200 feet; the Measures have thickened 50 feet per mile for each mile traversed through a horizontal distance of 16 miles, the thickening in the first four miles amounting to no less than 82 feet per mile, and 60 feet for the next five miles, the average of 50 feet being produced by the last six miles, only increasing at 20 feet per mile. At Burnley the Measures have thinned 64 feet per mile down to about 850 feet.

The researches of Bischoff, Graham, and Playfair as to the natnre of the explosive gases evolved by coal, show that in addition to containing from 66 to 94 per cent. of light carburetted hydrogen, nitrogen is always present, and sometimes amounts to 14 to 21 per cent. of the entire volume, which can alone be explained by "supposing that air has permeated the fissures of the coal, and, acting upon it, has been robbed of its oxygen, partly by union with hydrogen, and partly with carbon." The presence of carbonic acid points out that the process of decomposition is still going on in the coal, and that woody fibre not only loses carburetted

hydrogen in passing into coal, but by a process of oxidation, carbonic acid and water also.

The large quantity of protoxide of iron (4·73), found by Dr. Frankland to occur in the under-clay of a coal-seam, has an important bearing on the origin of coal.

The extensive peat mosses of West Lancashire which fringe the margin of the land and dip beneath the sea, with prostrate forests at their base, exhibit clear evidence of the obstruction of drainage at a period immediately antecedent to their destruction—possibly as suggested by Mr. Binney, by a bank thrown up by the sea—which threw the country behind into a state of morass and bog, which would prevent free ingress of air to the soil, and consequently to the roots of the trees growing in it, which cut off their supply of oxygen, which forms the essential constituent of the sap, and exists in larger proportions in the spiral vessels than it does in air.

The fallen leaves and branches would be placed in a position favourable to decay, not merely by the mere action of the air, which would be to a great extent excluded, but the organic matter would act upon the peroxides of iron in the soil, and rob it of its oxygen. After all the iron in the soil was reduced to peroxide, a complete barrier to the entrance of oxygen to the living roots would exist, for all fresh oxygen absorbed by the soil would be appropriated by the lower oxide, which on elevation to the peroxide would again yield it to the dead organic matter.

The trees would then be no longer able to exist, surrounded by matter poisonous to vegetable life, and cut off from an essential element for their sustenance, whole forests would easily be destroyed. In Lancashire, the water appears to have risen some two or three feet up the trunks of the trees, along which line, between air and water, great decay has taken place, and the trees have been abruptly broken by some agency acting along this line, before the growth of the peat, sometimes reaching a thickness of 30 feet, with which they are overlaid. As most of the trunks lie in one direction parallel to each other, with their heads towards the E.N.E. or E.S.E., it would appear probable that they were violently snapped off by a westerly gale.

That some such sequence held good during the formation of the coal-seams of Carboniferous times, is supported by the fact that the

Underclays are so charged with protoxide of iron as to preclude any possibility of vegetable life; that notwithstanding this these Underclays are almost invariably traversed in all directions by *Stigmaria* and other roots of *Sigillarian* plants; that the trunks of *Sigillaria* and other tree-like plants are constantly broken across at a short distance from the original ground surface on which they grew, and have been surrounded, and often surmounted by layers of coal, which consists of finely macerated vegetable matter, and has been deposited in a stratified form, and is often overlaid by well-marked seams of the shells of *Anthracosia*, as well as by shales containing drifted ferns.

The preservation of the woody fibre would be due to the absence of air, while the subsequent decomposition under conditions of considerable pressure, and of tolerably high temperatures, would bring about the elimination of carburetted hydrogen, carbonic acid, and water, which form the "fire-damp," so much dreaded by the collier of to-day.

The laws affecting the thickness of the Measures of the Wigan and Burnley Coal-fields do not apply to that of the coal-seams, the aggregate thickness being in—

Column	I.—94·7	feet in 19	seams,	15	being over 2 feet.
"	IV—84·7	" 35	"	13	"
"	VII.—79·5	" 27	"	15	"
"	X.—52·7	" 19	"	14	"

The researches of Messrs. Herschel and Lebour on the thermal conductivity of rocks, have shown that the lighter and more porous the rock the greater its resistance to heat; the more compact and crystalline, the less is its resistance, granite and grit being at one end of the scale, shale and coal at the other.

Laminated and cleaved rocks have been shown by M. E. Jannettaz to resist the transmission of heat in the direction of the cleavage planes, only half as great as across them.

The varied character of the rocks making up the Coal Measures, shales, sandstones, and coals, with different degrees of conductivity, varying in amount in the same rock in different directions, will well explain the fact that the rate of increase of underground temperature is not absolutely the same in collieries, not far distant from each other, for when the strata are inclined and a

numerous series crop out at the surface, heat is more rapidly transmitted than across the planes of the bedding of the same strata where they lay horizontal.

At Rose Bridge, the deepest colliery in England, the beds dip at a long angle some seven degrees, and are bounded by large and important faults, bringing beds of low conducting shale against the terminations of the strata, and the temperature is found to rise at no less than one degree for every 54·3 feet. The temperatures were taken with great care by Mr. Bryham, the manager, and have been published by Professor Hull—that of the solid rock, at the Arley Mine, at a depth of 808 yards being 93½°F., the total depth of the Colliery being 815 yards, or 2,445 feet.

The largest of these shafts at Rose Bridge is 16 feet in diameter, and is what is called in Lancashire a "Furnace Pit," the ventilation being effected by three furnaces, all of which return into the Arley Pit, and set in motion no less than 250,000 cubic feet of air per minute, consuming five tons of coal per day. The heat in the shaft is very great, and in passing the furnace one's hand intuitively leaves go of the cage rails to screen the face, and the knowledge that were the cage to be arrested in its upward movement, that the heat is more than 200°F. adds to the excitement of travelling through vertical space at the rate of nearly a mile a minute.

The system of ventilation by furnaces is replaced in the newer Lancashire collieries by "Guibal Fans" of large size, especially those at Abram and Pemberton Collieries.

At Garswood Hall Colliery, at Bryn, the gas is piped off from this coal, and taken up to the deck of the colliery stage, burns continually, and may be seen for many miles, the length and strength of the flame increasing, when the barometer is low, pressure released, and a larger quantity of gas enabled to escape. How large an influence barometric pressure has upon the escape of fire-damp is shown by the observations of Messrs. Scott and Galloway, which show that 48 per cent. of the colliery accidents of this country are due to this cause, generally occurring in the break after a long calm, and sometimes not until two days after the minimum is reached.

The structure of coal differs not only in different beds, but in different parts of the same bed, the variation being partly due to the nature of the different plants of which the coal is composed,

and partly to the degree of subsequent metamorphism that the coal has undergone.

Some coals, like the "Better bed" of Bradford, described by Professor Huxley, are entirely made up of Sporangia imbedded in their shed microspores; these sporangia have also been detected in some of the Wigan coals. In nearly all of these, vegetable organic tissue is visible under the microscope, some showing punctated woody tissue indicating the presence of conifers, and others exhibiting the scalariform tissue due to the Ferns and such plants as the *Sigillaria* and *Lepidodendron*. In the Wigan Cannel Coal vegetable structure is seen throughout the whole mass, which is the case with other cannel and gas coals. The exact causes which produce the peculiar condition known as Cannel Coal is still unknown, scales of fish, *Megalichthys* and *Rhizodus*, occur, and in the roof, fish remains are very common, as they are also in that of the Arley Mine.

The Wigan Cannel Coal was used early in the seventeenth century. Camden, speaking of its discovery at Haigh, near Wigan, states "that this neighbourhood abounds with that fine species of coal called *can* or *candle*. It is curious and valuable, and, besides yielding a clear flame when burnt, and therefore used by the poor as candles, is wrought into candlesticks, plates, boxes, etc., and takes a fine polish like black marble."

The method in which the various seams of coal, with their alternating beds of shale and sandstone, have been produced, is well exemplified in many sections in the Lancashire peat mosses, where trunks of large trees may be seen at the base of the peat, with their roots ramifying into the grey clays beneath, while other grey clays and sandy bands intersect the peat, and divide it up into distinct portions, just as the so-called dirt-bands traversing the coal are constantly observed to do. The amount of carbonaceous matter required to form a bed of coal is immense; Maclaren has calculated that one acre of coal three feet thick is equal to the produce of 1,940 acres of forest.

Sir Charles Lyell believed "that the plants which produced coal were not drifted from a distance, but nearly all of them grew on the spot, where they became fossil. They constituted the vegetation of low regions, chiefly the deltas of large rivers, slightly elevated above the level of the sea, and liable to be submerged beneath the waters of an estuary or sea by the subsidence

of the ground to the amount of a few feet. That the areas where the Carboniferous deposits accumulated were low, is proved not only by the occasional association of marine remains, but by the enormous thickness of strata of shale and sandstone to which the seams of coal are subordinate."

In Lancashire, the Upper, Middle, and Lower Coal Measures have a united maximum thickness of 8,000 feet, or more than a mile and a-half, exclusive of the underlying Millstone Grit. Such a thickness implies a constant flow of water carrying detritus from large islands, or continents to a given area through indefinitely long periods. The presence of so large a number of ferns would indicate a climate similar to that of New Zealand at the present day, and, as Mr. Bunbury has pointed out, the peculiarity of the Carboniferous climate consisted more in the equable temperature preserved in the different seasons of the year than in its tropical heat.

The object of this Paper is chiefly to describe the general character of the West Lancashire Coal-field, but it may perhaps be unadvisable to omit all reference to the Manchester Coal-field, an isolated tract of Upper Carboniferous rocks surrounded on all sides by those of Triassic and Permian age, and occupying an area of four square miles, the general section being :—

	FEET.
Limestone series	600
From the Limestone to the *Openshaw coal* .	600
From the *Openshaw coal* to the *Yard coal* .	485

Below these strata lie some nearly 2,000 feet of barren ground, separating this field from that of Lancashire, consisting of reddish sandstones and shales.

At Bradford and Clayton, the "*Four Feet Mine*" occurs 108 feet above the Yard Mine, and perhaps may be taken as the base of the Upper Coal Measures, as it is believed to be the equivalent of the *Worsley* and *Pendleton Four Feet*.

In the Limestone series of Ardwick, the calcareous members of the Carboniferous are more fully developed than elsewhere in Britain, six beds occurring with an aggregate thickness of 15 feet of limestone, the lowest and thickest being six feet; the next above, a black-band ironstone, with *Anthrocomya* of six inches.

The limestones contain *Spirorbis carbonarius* and fish remains, as *Ctenodus*.

At Patricroft, west of Manchester, the Upper Coal Measures have been penetrated in a colliery shaft, which passes through the Permian marls and sandstones, resting unconformably on 10 feet of Coal Measure shales, lying on two feet of calcareous hematite, forming a valuable iron-ore, containing 22 to 26 per cent. of metal with 40 per cent. of carbonate of lime, the iron varying from a carbonate to a peroxide. It occurs at 44 yards and 396 yards above the Worsley Four Feet seam, which has been sunk to in this shaft.

To sum up the sequence of events in West Lancashire, it appears probable that the Coal-fields of Wigan and Burnley were deposited in basins of subsidence, and lie in contemporaneous synclinals, the axis of subsidence in the western area coming first into existence at Preston and St. Helen's, and gradually travelled to the north eastwards in time, until it rested on Worthington, near Wigan.

That notwithstanding the enormous thickness of the Yoredale Series, Millstone Grit, and Coal Measures up to the base of the Arley Mine, were formed in a sea of no great depth, in which from time to time the sea bottom was either elevated so as to become a land surface, or else these barriers of sand or mud, at the entrance of inlets kept the sea out, while plant-growths came into existence on the higher grounds.

The sea not attaining any great depth, and the amount of deposition keeping pace with the rate of subsidence, the same depth was maintained, and the same marine organisms were able to exist throughout the whole period.

At the base of the Middle Coal Measures, a change takes place. Some erosion of previously formed beds occurred, the pauses in subsidence appear to have lasted longer, and occurred oftener, plant growth succeeding plant growth; thicker coal-seams were the result, freshwater conditions were more prevalent, though it is probable that the fish occurring were like the salmon, capable of living in sea water as well as fresh, and though the same species of fish are found in successive horizons, probably of freshwater origin, it is possible that the fish lived on in some outer area of salt water during the entire interval.

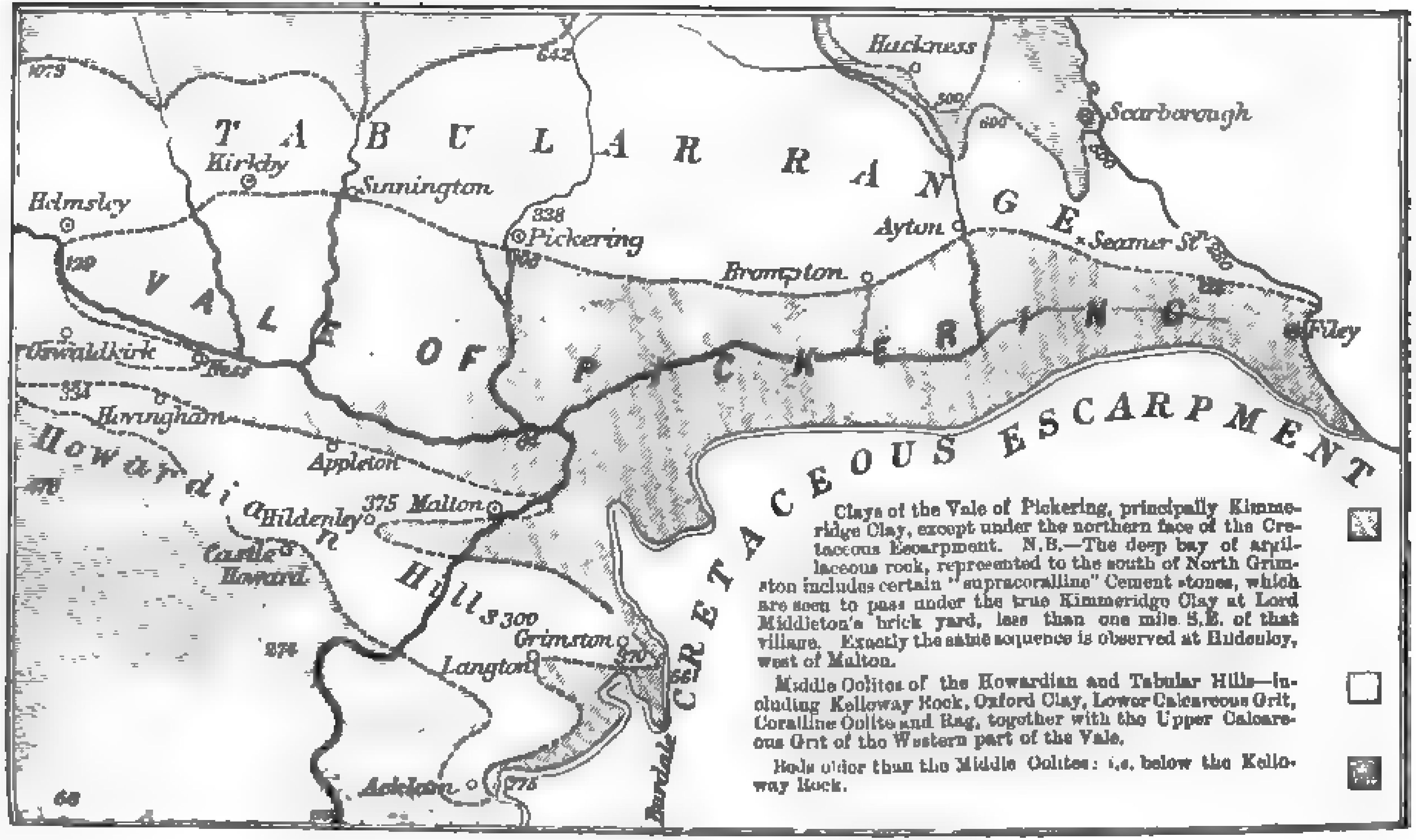
The Wigan cannel, occurring as it does at its maximum thickness precisely at the point where the subsidence was greatest, the nodal point of the curve of subsidence, formed as the researches of Mr. Binney have shown, of excessively comminuted vegetable matter, spores of Lycopodiaceous plants being common in it, and large fish-scales often occur in it, which would point to tranquil deposition of vegetable matter, which had long been macerated and submerged.

The deposition of the Coal Measures and formation of the coal-seams were followed by continued subsidence, which caused the Carboniferous rocks to be rolled into a series of flexures, the crests of which were denuded before the deposition of the Permian rocks, which rest upon the eroded edges of Upper, Middle, and Lower Coal Measures, various Millstone Grits, and the Yoredale-beds.

After the Permian era, a series of lines of faults ranging N. and S., followed by a still later one along N.N. Westerly lines.

Mr. Wilson's researches render it tolerably certain that subsidence of a curved surface inevitably results in the contortion of strata, while faults are its cracks, the result of the re-elevation of that curved surface.

The subsidence that brought about the E.N.E. synclinals of the Lancashire and Yorkshire district, the anticlinals of the Mendips and the Ardennes, was followed by an elevation at the close of the Permian Epoch, which brought about the Pennine anticlinal.



AMENDED SKETCH MAP OF THE COUNTRY SURROUNDING THE VALE OF PICKERING.

ORDINARY MEETING, May 3rd, 1878.

Professor J. Morris, F.G.S., President, in the Chair.

The following Donations were announced :—

"Journal of the Society of Arts," Nos. 1325, 27, 28; from that Society.

"Abstract of Proceedings of the Geological Society of London," Nos. 351-352; from that Society.

"Transactions of the Watford Natural History Society," Vol. i. pt. 9; from that Society.

"Annual Report of the Royal Cornwall Polytechnic Society, 1877;" from that Society.

"Description de quelques espèces nouvelles de la Craie de l'est du Bassin de Paris," by Dr. Chas. Barrois; from the Author.

"Les Sables de Sistonne," &c., by Dr. Chas. Barrois; from the Author.

"Note sur les traces de l'époque glaciaire en Bretagne," by Dr. Chas. Barrois; from the Author.

The following were elected Members of the Association:—

John Eunson, Esq., F.G.S., F.M.S., &c.; R. Nuttall, jun., Esq.; Charles Edward Paget, Esq.; Philip Edward Vizard, Esq.

The following Paper was read :—

The Yorkshire Oolites—Part II., Section 2. The Coralline Oolites, Coral Rag, and Supracoralline Beds.

By Wilfrid H. Hudleston, Esq., M.A., F.G.S., &c.

Table of Contents.

The introduction to Part ii. of the Yorkshire Oolites,* deals briefly with the whole of the Middle Oolites, including beds of every description, which occur between the top of the Cornbrash and the base of the Kimmeridge Clay. In Part ii. Section 1, a full description of each formation is given, as far as the top of the Lower Calcareous Grit, including the coast exposures at Scarborough and Filey, where the Lower Calcareous Grit is seen to be passing upwards into a group of limestones more or less oolitic.

The present paper, which concludes the series written upon the Yorkshire Oolites, is intended to deal with the subject of these limestones, which everywhere within the area have for their base the Lower Calcareous Grit proper. Barely seen on the coast, they have an extensive development inland, where they are variously known as Coralline Oolite and Coral Rag, and are covered in many places by a series of subcalcareous shales, grits, &c., which are interposed between the top of the Coral Rag and the base of the Kimmeridge Clay.†

Where there exists a series of beds having considerable variety within certain limits, the question of names is always a difficult one. In Yorkshire the Corallian Limestones have usually been called Coralline Oolite, whilst in the South of England Coral Rag is the more frequent term. If we select for the group a petrological distinction of this sort, naming the entire formation after one of its subdivisions, there is always the danger of confounding the part with the whole, to say nothing of the erroneous notions arising from affixing a definite petrological character to beds of considerable variety. Thus an idea has prevailed amongst some that there was no Coral Rag in Yorkshire, although there are far finer displays of this class of rock there than in any part of the South of England. Again, in the North, there are found two very distinct Oolites, forming portions of the Upper and Lower Limestones of Mr. Fox Strangways respectively. We might, it is true,

* Proc. Geol. Assoc., Vol. iv., p. 353.

† It should be borne in mind that the Corallian Limestones as a group, along with their associated underlying and overlying Grits and Shales, are by no means continuously developed throughout England. They may be regarded as the result of a peculiar phase of conditions obtaining locally towards the middle of the Oxford-Kimmeridge stage. It is probable, however, that these conditions would not be without their effects on the contemporaneous clays, as has been pointed out by Professor Seeley.

call the whole "Coralline Oolite," or "Coral Rag," as suits the fancy, and indicate the several subdivisions by letters simply. But for most people this is too abstract a way of dealing with the question, and therefore, even at the risk of some misunderstanding, it is best to make use of names already existing as far as this is practicable, and indicate, in a tabular form, their more exact geological value.

As regards the period assigned to the deposits in question, we are again met by the difficulty of names. I have already expressed the opinion that "the name Corallian must be deemed a mere matter of convenience, not representing a formation in time."* It does, in point of fact, represent somewhat different periods in different districts throughout Europe, and there are fair reasons for presuming that the more northerly Corallian Deposits are the oldest. Such being the case, their chronological import is more than doubtful—it is misleading—and for this reason De Loriol and Pellat† propose to suppress altogether the term "étage corallien." We are thus left with the major divisions, Oxfordian and Kimmeridgian, out of which to construct the geological clock of the White Jura, and we must regard Corallian deposits as pointing to slightly different figures in different places. These are generally in the centre, but with a tendency to advance the lower the latitude. If, therefore, we get rid of the element of time, and view the Corallian Limestones simply as an important, but yet sporadic manifestation of the existence of reef-building corals in the Oxford-Kimmeridge sea, we may use the old names with safety. Moreover, if we construct our geological clock of reliable materials, it will be possible ultimately to assign to each Corallian Deposit of the White Jura throughout Europe its proper position in the chronology of the entire system. Approximately we may regard the lower portions of our area as Oxfordian, whilst the upper portion, representing the sub-zone of *Cidaris florigemma*,‡ and yet higher beds, prefigures to a certain extent the Kimmeridgian fauna as known to us in the South.

* "Proc. Geol. Assoc.," Vol. iv., p. 334.

† "Monog. des ét. sup. de la form. Jur. de Boulogne," Part ii., p. 320.

‡ Mons. Rigaux, of Boulogne-sur-Mer, has expressed his surprise to Mr. Blake that so much importance should be attached to the presence or absence of this fossil. Since this paper was read I have had the good fortune to make Mons. Rigaux' acquaintance during the recent Excursion of the Association, and to hear his views upon the subject. It must be admitted that *Cidaris florigemma* appears to range lower in the Corallian Limestones

With a view of affording at the outset a fair idea of the average development and character of the great belt of Corallian Limestones which partially encircles the Vale of Pickering, a generalized section has been constructed from data obtained chiefly in the interior, as the higher beds are not to be seen upon the coast. It will be perceived in the sequel that the variations are so considerable as to preclude us from doing more than loosely to fit each group into its appropriate place. Treating the subject in this way, we may preserve for each series of Shelly Limestones, Oolites, and Rag-beds their separate individuality, and yet feel sure that we are right in correlating them within certain limits. The varying details of this old sea-bottom, as obtained in the numerous quarries and natural sections, may thus be presented to us with a fidelity which it is impossible to attain in respect of deposits now in course of formation.

The deposits which underlie the Kimmeridge Clay in Yorkshire, may be grouped in descending order as follows:—

Red Grits, Shales, and Argillaceous Limestones, THE SUPRA-CORALLINE BEDS.

Flaggy Shelly Beds, Hard Crystalline Limestones with Corals, and soft Intercoralline Brash, often very fossiliferous, sub-zone of *Cidaris florigemma*, THE CORAL RAG.

Oolites and pasty Limestones, with or without Shell-beds, characterized by multitudes of *Chemnitzia* and *Nerinæa*, Corals rare, THE CORALLINE OOLITE.

A Middle Calcareous Grit in the Tabular Range, included palæontologically with the Coralline Oolite.

Thick masses of Oolite poor in fossils, but with shelly beds sometimes at top, but more especially towards the base, which is an impure limestone, Corals locally, THE LOWER LIMESTONES AND PASSAGE BEDS.

The further subdivisions may be studied in the accompanying Table:—

The two first groups belong, in a certain sense, to the Kim-

of the Boulonnais than we have any proof of its doing in this country. In Yorkshire, however, its almost total absence from the Lower Limestones and from the lower division of the Upper Limestones (Coralline Oolite), when contrasted with its abundance in the Coral Rag, makes it a very reliable "leit-fossil" throughout the region described in the present paper.

IATION.	S.		SOME OF THE CHARACTERISTIC FOSSILS.
ORALLINE wanting in aces.	cherty, les. s, very nd soft		*Belemnites nitidus*, Dollf. *Am. varicostatus*, Buckl. *A. alternans*, Von Buch. *Ostrea bullata*, Sow. *Gryphæa subgibbosa*, Bl. & H. *Pecten Midas*, D'Orb. *Modiola cancellata*, Röm. *Lucina aspera*, Buvig. *L. substriata*, Röm. *Thracia depressa*, Phil. *Goniomya*, *Pleuromya*, &c.
, sub-zone of lorigemma. 40 ft.	astræa f Rhab- oralline n mas- t and massive , rarely	*Zone of A. plicatilis.*	*Am. varicostatus* (Buckl.) var. of *A.* plicatilis. *Purpuroidea nodulata*, Y. & B. *Natica globosa*, Rœm. *Cerithium limæforme*, Rœm. *Nerinæa Rœmeri*, Goldf. *Littorina muricata*, Sow. *Turbo funiculatus*, Phil. *Ostræa duriuscula*, Phil. *Pecten vimineus*, Sow. *Lima pectenifomis*, Schlot. *Arca quadrisulcata*, Sow. *Astarte rhomboidalis*, Phil. *Opis virdunensis*, Buvig. *Terebratula insignis*, Schübl. *Cidaris Smithii*, Wr. *C. florigemma*, Phil. *Hemicidaris intermedia*, Flem. *Pseudodiadema hemisphæricum*, Ag.—CORAL RAG. *Belemnites abbreviatus*, Mill. *A. plicatilis*, Sow. *A. cordatus*, Sow. *Chemnitzia heddingtonensis*, Sow. *Nerinæa visurgis*, auct. *Cerithium muricatum*, Sow. *Pecten intertextus*, Rœm. *Cucullæa corallina*, Damon. *Trigonia Meriani*, Ag. *T. perlata*, Ag. *Lucina aliena*, Phil. *Astarte Duboisiana*, d'Orb. *Pygurus Hausmanni*. K. & D.—CORALLINE OOLITE. N.B.—The top shell-bed of the Lower Limestones is included with the Coralline Oolite palæontologically.
NE OOLITE. 35 ft.	n Coral- art. y Lime- , calca- granules netimes me.		
CALCAREOUS RIT. 45 ft.	t, some- where it erlying		
LIMESTONES 120 ft. above figures represent the te *maxima* and *a* of each ion.	s, fre- ch used Oolites, ried for ormerly es, often ot. well s, with stones.	*Upper Part of Zone of A. perarmatus.*	*Belemnites abbreviatus*, Mill. *A. perarmatus*, Sow. *A. cordatus*, Sow. (*excavatus.*) *A. goliathus*, d'Orb. *Cylindrites elongatus*, Phil. *Avicula ovalis*, Phil. *A. expansa*, Phil. *Pecten fibrosus*, Sow. *Gervillia aviculoides*, Sow. *Myacites*, *Pholadomya*. *Echinobsissus scutatus*, Lam. *Holectypus*. *Ammonites Williamsoni*, Phil, *A. goliathus*, d'Orb. *Avicula ovalis*, Phil., and *expansa*, Phil. *Gervillia aviculoides*, Sow. *Trigonia clavellata?* Sow. *T. triquetra*, Von Seeb. *T. Snaintonensis*, Lyc. *Sowerbya triangularis*, Phil. *Waldheimia buculenta*, Sow. *W. Hudlestoni*, Walk. *Terebratula fileyensis*, Walk. *Rhynch. Thurmanni*, Voltz. *Glyphea rostrata*, Phil. *Millericrinus echinatus*, Goldf. *Spongia floriceps*, Phil.
ER CALCAREOUS *GRIT proper.*			

meridgian* subdivision: of these the Coral Rag is richly fossiliferous, and has many features of its own. The Coralline Oolite, or third group has a still more special character, but with a leaning towards the Oxfordian fauna. To this group are assigned the few fossils of the Middle Calc Grit, and for the most part the top shell beds of the Lower Oolite. The fossiliferous beds at the base of the Lower Limestones may be referred, along with the whole of the Lower Calcareous Grit, to the Oxfordian division.

The Lower Calcareous Grit proper has already been fully dealt with in Section 1, together with such portions of the Lower Limestones as may be seen on the coast at Filey and Scarborough. The mass of these Lower Limestones, however, in the Tabular Range, is so important, that I propose to commence with a description of them, adding at the same time such references as may be necessary for the explanation of those portions already described in Part ii., Section 1.

I. The Lower Limestones and Passage Beds (D).

This group may be defined as a mass of calcareous rock, oolitic in part, of an elliptical shape, the longer axis running E. and W., or in the same direction as the Tabular Hills, where, from the Vale of Thirsk to the German Ocean, the group is largely developed, its eastern termination being on the coast.

The whole of the Limestones of Scarborough Castle Hill above the Ball-beds belong here, as likewise that portion of the Filey section which underlies the Filey Brigg Calcareous Grit (Middle Calc Grit).† At the latter place its altering character and diminishing thickness lead us to suppose that, as an oolitic limestone, it must have had its original termination not far to the S.E. of where that promontory now is. Its *southern* limits are for the most part unknown, as usually where we meet with the Lower Limestones on the slopes of the Tabular Hills, they are seen to be passing underneath higher beds, and are thus lost to sight; and

* It is true that there is not much analogy between the fauna of the Coral Rag and that of the Yorkshire Kimmeridge Clay, but the basement beds of this latter are very little known.

† Cf. Proc. Geol. Assoc., Vol. iv., pp. 396 and 400, and Quart. Jour. Geol. Soc., Vol. xxxiii., pp. 318 and 324. It will be understood, therefore, that the Oolite of Scarborough Castle is the Oolite of the Lower Limestones.

even if this was not the case, they must be cut off, as they are seen to be at Wydale by the great fault which runs at the foot of the Tabular Range. Their possible re-appearance on the opposite side of the Vale of Pickering (Howardian Hills), will be considered subsequently. The *western* limits of the group must be sought in the Hambleton escarpment, overhanging the Vale of Thirsk (without the limits of the sketch-map, Plate iii). On the brow of this escarpment, at a place called Kepwick, 1,000 feet above the level of the sea, a mass of small-grained gritty Oolite, 50ft. thick, and remarkably unfossiliferous, is extensively quarried for lime. The series is here split by a (fourth) grit, for the flaggy oolites on the top of Hambleton Moor (Cold Kirkby, &c.), are somewhat higher in the series than those of Kepwick, which are dying out as we follow them to the south. That the Hambleton Oolite itself also thins rapidly to the south, may be proved.* Therefore there seems reason to suppose that the original limits of this mass of limestone on the S.W. are capable of approximate definition. The *northern* limits of the Lower Limestones are to be sought at varying distances from the edge of the northern escarpment of the Tabular Range.

At Cropton, where this range is much indented and depressed, they appear in full force on the face of the escarpment itself, and thus some of the finest inland sections are obtained. Hence it is evident that we are not anywhere near its original limits at this point; but if we trace the northern boundary still further to the east, there are said to be indications of this limestone thinning out to a feather edge, and this would seem to tally with its known diminution from Forge Valley (Ayton) to Hackness. Its original limits, therefore, on the N.E. are also capable of approximate definition.

The line of maximum thickness along the major axis is not very easy to ascertain, for the same reasons that obscure the southern margin of this group; but it is not improbable that this may be found not far from the roots of the Tabular Hills, though, as we travel from E. to W., the position of this line seems to recede rather further from the edge of the vale. Mr. Fox Strangways considers that the maximum thickness along the N. and S. or shorter

* Quart. Jour. Geol. Soc., Vol. xxxiii., p. 356.

axis of the ellipse, occurs about Kirkby Moorside, where he estimates it at 150ft., nearly all oolite, without much Passage-bed rock. It is on this meridian, therefore, that we might expect to find the oolite of the Lower Limestones again on the opposite or Howardian side of the vale, after suffering the eclipse which all these Corallian beds undergo beneath its enshrouding clays. The usual thickness in the oolite quarries of this formation is about 40ft., often less, seldom more; but it is evident that, where well developed, it attains a greater thickness than any portion of the Upper Limestones (Coralline Oolite and Coral Rag) of the Tabular Range.

On reviewing the evidence as to its extent and development, the body of the Lower Limestones, apart from its interest as a local feature amongst the Corallian Rocks of Yorkshire, seems to afford a good instance of an ovately lenticular mass, principally oolitic, occurring as a sort of swelling in the midst of a great formation of Calcareous Grit. The actual proof, however, of its original shape can only be inferred at present, in consequence of our inability to trace its southern boundary.

Divisions.—A considerable variety of beds have been grouped under the general term Lower Limestones. The basal portions are very gritty, and afford examples of a lithological passage between Calc Grits and Oolites. This is better seen in the Scarborough district, and especially in the two coast sections, than elsewhere; for in the western portion of the Tabular Range, and in the Hambleton escarpment, the type of these basal beds changes, and they, at the same time, become less fossiliferous. Following out the plan adopted in the Generalized Scheme, it will be convenient to place these basal beds by themselves.*

LOWER DIVISION.—1. *Passage-beds at the base of the Lower Oolite in the eastern district.* The details of these beds, as seen on the coast, have been very fully given already in a previous communication (Part ii., Sec. 1.) The ferruginous character of the lower part of the Passage-beds throughout the Scarborough district is a distinguishing feature, and may be noted at Hackness, where there is a very interesting development, including a Lower Coral Rag.

* In the subsequent pages these are spoken of sometimes as the Lower Passage-beds, to distinguish them from the Upper Passage-beds at the base of the Coralline Oolite of Pickering.

Section of Corallian Rocks at Hackness.

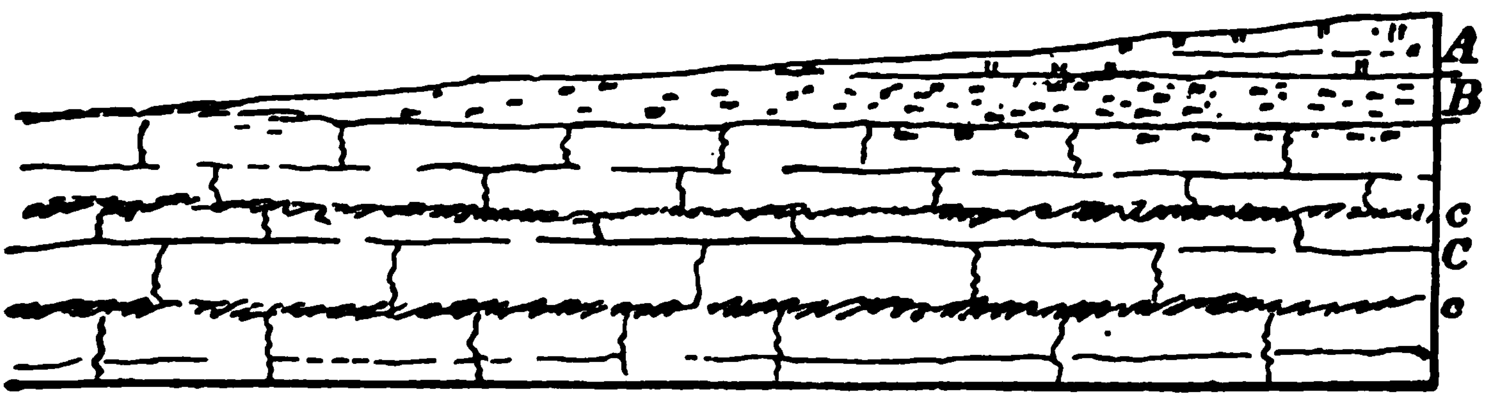
		FT.	IN.
	1. Upper Calcareous Grit, partly *in situ*, and partly occurring as a fragmentary wash covering the fields to the north of Loffeyhead Heights.		
Upper Limestones.	2. Upper or true Coral Rag—a crystalline limestone made up of roundheads of *Thamnastræa concinna*....	12	0
	3. The Bell-heads Limestone, or equivalent of the Coralline Oolite, made up of large oolitic granules in a dense greyish paste, and containing towards the centre a strong band of *Thecosmilia*-rag full of fossils.	18	0
	5. Thin bands of gritty limestones and sandy beds—Middle Calcareous Grit.		
Lower Limestones.	4. The Lower Oolitic Series. Small-grained oolites towards the centre of the mass with flaggy limestones towards the top and thick-bedded fossiliferous limestones towards the base—the rock of the lime-quarries of Silpho and Suffield.	18	0
	6. Lower Coral Rag: a brown ferruginous coral limestone, with brashy partings and interspaces, having a peculiar set of fossils.	8	0
	7. Basement- or passage-beds: a series of impure, gritty, and rather flaggy limestones, in some places made up of comminuted shelly matter, and generally very ferruginous; quarried for walling and road-mending.	24	0

The fossils of the Lower Coral Rag are numerous and interesting. There are some peculiar forms of *Ostrea.* The list includes *Ostrea*, sp., *O. gregaria*, *O. solitaria*, *Exogyra nana*, *Gryphæa chamæformis ? Pecten fibrosus*, *P. articulatus* (dwarf), *Hinnites velatus*, *Lima rudis*, *Lima*, sp., *Trichites*, *Cypricardia* (small), *Astarte rhomboidalis* (small), *Waldheimia Hudlestoni*, *Cidaris Smithii*, *Spongia floriceps*, *Serpula squamosa.* The corals present more variety than might be found in an equal amount of the Upper (true) Coral Rag of the district. *Isastræa explanata*, *Thamnastræa concinna*, *Thecosmilia annularis*, and *Rhabdophyllia Phillipsi*, with the inevitable *Modiola inclusa*, may be seen. The "sandstone" quarry on Suffield Heights is the best place for collecting.

The horizon of this Lower Coral Rag, distinctly traceable both at Scarborough and Filey, though without the corals, is generally marked by *Spongia floriceps*, and numerous small Brachiopods, and, indeed, throughout the eastern districts the shell-beds seem generally to be near this horizon. Hence it is interesting to note how this vertically limited group holds true for some horizontal distance, though a growth of coral in any quantity on this horizon

is now preserved to us at Hackness only. In Forge Valley, which also yields an admirable section of the entire Corallian series, the equivalents of the Scarborough Castle *Gervillia*-beds are poor, but the irony series (Red-beds) tolerably fossiliferous. Proceeding westwards the types begin to change, but we meet with a very rich shell-bed in a quarry at Wydale, about one mile west of Brompton, evidently in the Passage-beds.

* FIG. 14.—QUARRY AT WYDALE—WEST END.



One inch to 25ft. vertical.

A. Flaggy, suboolitic limestone, sometimes merely a rubble.
B. Shell-bed, a sandy limestone with very fine-grained oolite.
C. Block gritty limestones, blue centred. c. soft sands.

Immense quantities of *Gervillia* project from the shell-bed, and with these are associated an interesting group of small *Trigoniæ* (two species being new), three species of *Astarte*, and all the Brachiopoda found on this horizon. For the list of those actually collected consult the table.

Westwards from this quarry no good places for collecting are known to me in these Passage-beds, though at Cropton they have yielded immense specimens of *Gervillia*.

2. *Cherty Limestones of the western districts.* The eastern type of Passage-beds seems to have died out in this direction, or at least to have become so cherty and unfossiliferous as not to be recognised ; and in the Hambleton escarpment no shell-beds of any consequence are seen to mark the series between the Calc Grits and the Oolites. An uninviting formation, as far as my limited acquaintance with it extends.

3. *Passage-beds in the Howardian Hills.* The basement Limestones, which rest immediately upon the Lower Calcareous Grit at Appleton, are good examples of a fossiliferous phase. The stone resembles that in the analogous position at Filey, rather than the

* N.B.—The figures in this paper are numbered according to their order in the entire series of "The Yorkshire Oolites."

Scarborough or northern type, consisting of sandy speckled limestones of considerable hardness, varying from buff to blue. Sometimes the stone looks as if it were partly made up of fig-seeds. The following fossils may be deemed characteristic :—

Ammonites cordatus (excavatus), *Sow.*
A. goliathus, *d'Orb.*
A. perarmatus, *Sow.*
Pecten fibrosus, *Sow.*
Avicula ovalis, *Phil.*
A. expansa, *Phil.*
Trigonia snaintonensis, *Lyc.*
Waldheimia bucculenta, *Sow.*
Rhynchonella Thurmanni, *Voltz.*
Glyphea rostrata, *Phil.*
G. scabrosa, *Phil.*
Echinobrissus scutatus, *Lam.*
Millericrinus echinatus, *Goldf.*

UPPER DIVISION.—1. *Oolites underlying the Middle Calcareous Grit of the Tabular Range.* This division constitutes the great bulk of the formation. The Oolite on the summit of Scarborough Castle Hill belongs here, and it may be traced in the numerous natural sections and quarries throughout the Tabular Range, generally at some distance from the edge of the vale. There are but few fossils as a rule, hence the exposures are lacking in interest. *Cylindrites elongata, Rhynchonella Thurmanni, Gervillia,* and some of the species of the Passage-beds may be noticed sparingly in the eastern divisions. A line of coral growth may also be noted in some of the quarries in the region east of Pickering, whilst, in the western part of the range, the silicification of the lower beds presents us with some interesting examples of oolite turned into flint.

2. In the Hambleton Hills (beyond the sketch map) this oolite of the Lower Limestones is, if possible, still less fossiliferous, as may be gathered from previous remarks with reference to the quarries at Kepwick and on Hambleton Moor, though a closer search might yield more satisfactory results.

3. The possible representatives of the oolite of the Lower Limestones in the Howardian Hills will be treated under the head of Coralline Oolite.

The fauna of the Lower Limestones generally, including, of course, the Passage-beds, is very much that of the Lower Calcareous Grit, making allowance for change of conditions. But it must be admitted that the mass of the rock has been very little searched, and that our knowledge is, in a great measure, limited to those beds which are situated in the eastern portion of the Tabular Range. The central mass contains no shell-beds of consequence in

any portion of the area under description, but towards the middle of the Tabular Range there is a shell-bed of considerable horizontal extent at the top of the series. This is chiefly interesting from the very great change in the fauna, which may be said to prefigure the Coralline Oolite to a certain degree, and for that reason, in the Tables, is included, though not without doubt, in that subdivision. The following fossils have been found in this top bed at three different points, viz., Thornton West, Newtondale, and Sinnington—

Belemnites abbreviatus, *Ammonites cordatus*, *Chemnitzia heddingtonensis*, *Exogyra nana*, *Anomia radiata*, *Pecten lens*, *P. fibrosus*, *Avicula pteropernoides*, *Avicula* cf. *Struckmanni*, *Perna* (large species), *Gervillia aviculoides*, *Trigonia* (clavellate sp.), *Opis Phillipsi*, *Lucina globosa*, *Astarte depressa*, *Homomya tremula*, and *Myacites* sp.

Subjoined is a list of the more common or characteristic fossils of the Lower Limestones, excluding the above-mentioned top-bed :—

Ammonites Williamsoni, *Phil.*
„ goliathus, *d'Orb.*
„ cordatus, *Sow.*
„ vertebralis, *Sow.*
Alaria bispinosa, *Phil.*
Pleurotomaria Münsteri, *Goldf.*
v. c. Cylindrites elongata, *Phil.*
Goniomya litterata, *Sow.*
Myacites, &c., several forms.
c. Astarte extensa, *Phil.*
c. Trigonia clavellata, *Sow.*
„ triquetra, *Von Seeb.*
„ snaintonensis, *Lyc.*
Arca æmula, *Phil.*
v.c. Gervillia aviculoides, *Sow.*
c. Avicula expansa, *Phil.*
c. „ ovalis, *Sow.*
Lima læviuscula, *Sow.* var. c.
„ gibbosa, *Sow.*
v. c. Pecten sub-fibrosus, *d'Orb.*
v. c. Exogyra nana, *Sow.*, includes E. spiralis, *Goldf.*
Ostrea flabelloides, *Lam.* (var.)
Terebratula fileyensis, *Walk.*
Waldheimia Hudlestoni, *Walk.*
v. c. Rhynchonella Thurmanni, *Voltz.*
Cidaris Smithii, *Wr.* (small).
Acrosalenia decorata, *Haime.*
Collyrites bicordata, *Leske.* (small.)
Echinobrissus cf. clunicularis *Lhwyd.*
v. c. Echinobrissus scutatus, *Lam.*
Pygurus pentagonalis, *Phil.* (small.)
c. Millericrinus echinatus, *Goldf.*
Spongia floriceps, *Phil.*

The following Corals occur at Hackness in this series :—

Thecosmilia annularis, *Flem.*
Rhabdophyllia Phillipsi, *E. & H.*
Isastræa explanata, *Goldf.*
Thamnastræa concinna, *Goldf.*

II. Group of the Coralline Oolite, C^1 & C.

As the Middle Calcareous grit (C^1) is a deposit of very irregular development, consisting for the most part of mechanically derived sediment with but few included fossils, except where it approaches the overlying limestones, it is treated palæontologically as part of the Coralline Oolite (Column ii. of the Table of Fossils). Indeed, as the top bed of the Lower Limestones is included in this subdivision, the Middle Calcareous Grit which separates them must, of necessity, be included also. *A. plicatilis*, along with some of the Cordati, is the prevailing ammonite, nor have I ever seen *A. Williamsoni* or *A. perarmatus*.

Briefly, then, the Middle Calc Grit (C^1) is a calcareous grit, usually very poor in lime, which, throughout the Tabular Range separates the Lower Limestones (D) from the Upper Limestones (C & B). At Filey, as we have seen, it forms the Brigg itself, still dividing the two shrunken representatives of the calcareous series, but elsewhere, east of the Derwent Gorge (Ayton), its presence is not particularly obvious. Towards the middle of the Tabular Range its thickness reaches from 40–45ft., inclusive of the *Trigonia*-beds. In this region, extending from Thornton, a few miles east of Pickering, to Sinnington, a few miles west of that town, the following relations between this sandy bed and the underlying and overlying limestones were made out approximately by Mr. Blake and myself from three different points, as follows:—

Impure suboolitic limestones with corals at the base of the Coralline Oolite of Pickering.

Middle Calc Grit.
- *Trigonia*-beds and building stones of the Pickering quarries.
- Building stones—few shells: base of the Pickering quarries.
- Lower part of the Middle Calc Grit seen at Highfields.
- Flaggy calcareous sandstone and hard blue rock slightly oolitic, with *A. plicatilis*. Highfields

Lower Limestones.
- Shell-bed atop of L. L., Highfields—(also at Sinnington, D, Fig. 16).
- Ammonite bed at Whitethorn quarry, near Cropton *A. perarmatus*, plentiful. *A. cordatus*, com. *A. goliathus*, com. *A. plicatilis*, rarer.
- Oolite of the Lower Limestones, Cropton.

It would, of course, be more satisfactory to trace a complete sequence in each of the deep valleys which intersect the Tabular Range instead of constructing a sectional sequence from three

* Proc. Geol. Assoc., Vol. iv., p. 400.

different points. But we are not altogether without evidence in this respect, for a complete sequence, as far as the relations of the Middle Calc Grit are concerned, may be seen in the gorge of the Seven between Pickering and Kirkby Moorside. See *postea*, p. 424. It is probable, however, that the thickness of the Middle Calc Grit in Newtondale (Pickering) considerably exceeds that shown in the Seven Valley, where the Lower Limestones, on the other hand, are fully 100ft. thick.

In Duncombe Park, just west of Helmsley, there is a copious development of these Middle Calc Grits. They form the base of the cliff supporting the terrace on which the magnificent residence of the Earls of Feversham is built, and have been quarried to some extent. Here the formation consists of strong blocks, doggers, and soft sands with spongious and fucoidal reliefs. The lower beds are of a soft brownish yellow stone, without a fossil visible; the upper beds are thinner and harder. These same beds in their extension westwards, appear as the loose reddish sands of Wass Moor, which probably have a thickness of 60ft. In the Howardian Hills the equivalents of the Middle Calcareous Grit are not yet determined, if indeed they exist.

We now come to deal with the Coralline Oolite (C) itself. This constitutes the lower subdivision of the Upper Limestones, and is, in fact, the base on which the great mass of coral limestone has been built. In describing its existing extent, it cannot well be separated from the overlying Rag. These two, then, forming the mass of the Upper Limestones, occupy the innermost portion of the belt of rocks which surrounds the Vale of Pickering for three-fourths of its circuit. This fixes the general position of the formation; the topographical details must be sought under the several subdivisions. The same remarks apply to this group as to that of the Lower Limestones, with reference to their disappearance beneath the clays of the Vale of Pickering; only that, in this case, the reappearance of the Coralline Oolite on the opposite or Howardian side, is undoubted, though with considerable change of type.

Both lithologically and palæontologically the Coralline Oolite presents a very great contrast to the Coral Rag. Yet there is no reason to suppose that the two were separated by any very great interval of time, the differences being due principally to physical conditions of deposit: still as the Coralline Oolite almost invariably underlies the Coral Rag, and is not merely intercalated with it, as

oolitic beds and coral beds might be in a large calcareous series, it is evident that the one preceded the other in time, and that each, therefore, is entitled to rank as a sub-formation in the Corallian system of Yorkshire. It should also be observed, in support of the above view, that, although a slight development of coral does take place towards the top of the Pickering *Trigonia*-beds, yet this is for the most part devoid of that peculiar fauna so characteristic of the larger aggregate of corals and coral *débris* called the Rag.

There is no positive evidence that all the beds within the area classed as Coralline Oolite are quite on the same geological horizon.

Whether the differences in the Coralline Oolite are the result of purely lateral variations, or are due to the deposits having been formed at slightly different periods, is a question not easily answered. We may feel pretty certain that every bed of oolite represents the destruction of a bed of coral somewhere in the vicinity. If the bed of coral has been totally destroyed, as seems generally to have been the case, we can merely infer its existence; but sometimes we have a fragment preserved, as already noted in the Lower Coral Rag of Hackness, whose lateral equivalents may be sought in the oolitic shell-beds of Wydale and other places. It so happens that the Upper Limestones are discontinuous in the tract between Brompton and a point about two miles east of Pickering, owing to a slight anticlinal at right angles to the general strike of the beds. The types on either side, both as regards Rag and Oolite, are materially altered. It has sometimes occurred to me that the whole of the Upper Limestones, Oolite and Rag, of the district between Seamer and Brompton, are older than much of the Coralline Oolite of Pickering.

Subdivisions of the Coralline Oolite.—1. *Oolites underlying the Rag of the Scarborough District (Seamer to Brompton).* The character of these in their fullest extent is best gathered in the gorge at the mouth of Forge Valley (Ayton), where a complete sequence of all the Corallian Rocks can be traced.* The base just above the uncertain representative of the Middle Calc Grit consists of shelly and gritty limestones, with very large *Chemnitzia*, *Astarte Duboisiana*, &c., and to these suc-

* Quart Journ. Geol. Soc., Vol. xxxiii., p. 320.

ceed rather gritty oolites. The upper portion of the series is best judged of in Seamer parish, where the following section may be noted, although the thicknesses vary within short distances.

SECTION OF THE CROSSGATES QUARRY, SEAMER.

		FT.	IN.
Coral Rag.	Soil, broken rock, and boulders of *Thamnastræa concinna* (roundheads)	2	0
Oolites and Corals.	Oolite in a buff pasty matrix, with a bed of *Rhabdophyllia* at the base	3	0
	Oolite in a buff pasty matrix, with a shell-bed at the base. *Nerinæa visurgis*, *Trigonia* (costate sp.), *Lucina*, sp., *Astarte Duboisiana*, spines of *Cidaris Smithii*, and a few delicate fingers of *Rhabdophyllia*	2	8
	Thin clay parting	0	1
	Shelly bed, partially oolitic. *Ammonites plicatilis*, *Nerinæa*, *Lucina*, *Astarte Duboisiana*, many *Rhabdophylliæ* and stray fragments of *Thamnastræa*. "Snake-bed"	1	4
	Indurated, cemented, large-sized pisolite, with an occasional coral. "The Top Hard."	1	0
The Coral shell-bed.	The Coral shell-bed. A pale grey oolite, rather pasty; shells and corals very sparry. Fragments of *Thecosmilia*, often prostrate, and principally in the upper portion; *Rhabdophyllia*; a few lenticular masses of *Thamnastræa* towards the base; *Pecten fibrosus*, *Lima rigida*, *L. densepunctata*, *L. pectiniformis*, *Perna rugosa*, *Trichites*, *Arca pectinata*, spines of *Cidaris Smithii*, very large; megalomorphic fauna. There is much comminuted shell in this bed. "The Bottom Hard."	2	0
Oolites.	Rubbly pisolite, full of small *Exogyræ*...	0	2
	Oolitic series, poor in shells, with an occasional brashy parting; excellent lime	6	6
	Rubbly pisolite, full of small *Exogyræ*; contains *Echinobrissus scutatus*, *Phasianella striata*, &c., a constant parting ...	0	6
	Fine-grained oolites, making excellent lime; some of the upper portions of the beds are rather lumpy, owing to casts of *Phasianella striata*, and to nodules which may represent sponges. There is one moderately shelly bed. *Exogyra nana*, *Pecten fibrosus*, *Gervillia aviculoides*, *Trigonia*, *Lucina*, &c., to base of quarry	6	0
		25	3

We here perceive a mere fragment of the Coral Rag of the district which is gradually lost on the rise. The upper part of this section is instructive, as showing an intermediate character. It is, in fact, a Coralline Oolite with Corals, principally the branching species, and contains a series of fossils, such as *Nerinæa visurgis*

and *Astarte Duboisiana*, which are so characteristic of the base of the Coralline Oolite at Pickering, whilst here they occur towards the top of the Oolite. The equivalent bed at the Ayton lime-quarry also contains these fossils, but I have never found them in the overlying Rag. The last glimpse of this Oolite is obtained at Brompton Keld, where a little cliff above the spring, surmounted by a grassy slope, discloses about 22 feet of this class of rock.

FIG. 15.—CORALLINE OOLITE AT BROMPTON KELD.

B. Coral Rag (out of sight from the point of view).
C. CORALLINE OOLITE of the Scarborough district.
a. Foundations of Brompton Castle in the Coral Rag at the top of the hill (out of sight).
b. Wall enclosing the Castle garth.
c. Road into the village.
d. The highest spring. *e*. Pool forming the head of Brompton beck.

The three lowest beds forming the little cliff, are strong blocks of Oolite in paste, one of the beds being slightly fucoidal and sandy. Above these is a *Thecosmilia*-band, which projects in relief from the grassy slope: it may correspond in part to the Coral Shell-bed of the Crossgates Section.

2. Chemnitzia-*Limestones, Oolites, and* Trigonia-*beds of the Pickering and Hambleton Districts*. By far the best exposures of this group occur at Pickering itself. The following generalized section is taken from the Paper by Blake and Hudleston on the Corallian Rocks of England:—*

* Quart. Journal Geol. Soc. Vol. xxii., p. 335, which consult for further details.

Generalized Section—Pickering (Newtondale).

Upper Division (supracoralline).—Grits, Shales, &c.

		FT.	IN.
A.	*a.* An Upper Calcareous Grit with abundance of tuberous and ramifying forms and many fossils in bad preservation.	7	0
	b. Sandy and marly shales resting upon a thin bed full of *Ostreæ*	10	0
	c. Bed of argillo-calcareous stone, locally termed "Throstler," wanting in places, or represented by a flaggy parting of a few inches	3	0
		20	0

Middle Division.—Upper Limestones.

		FT.	IN.
B.	*d.* Top-stone—a grey ferruginous limestone, generally false-bedded. The equivalent of the Coral Rag ...	5	0
C. and C.	*e.* Impure earthy limestones, known as "black posts," poor in fossils, but containing *Belemnites abbreviatus*, and towards the base *Ammonites varicostatus*	10	0
	f. *Chemnitzia*-limestones, compact and suboolitic. Shell-beds, at intervals full of *Chemnitzia* and *Nerinæa*; *Astarte ovata* and other bivalves less numerous... ...	20	0
	g. Variable limestones and pisolites, with shell-beds and nests of *Thamnastræa arachnoides* in the lower part; indications of Calc-Grit towards the base. Roadstones, walling, &c....	13	0
	CORALLINE OOLITE...	43	0

Lower Division.—Shell-beds and Grits (Middle Calc Grit in part).

		FT.	IN.
C. and C.	*h.* The upper part of this division contains the principal *Trigonia*-beds, full of fossils alternating with Calc Grits, *Ammonites plicatilis* abundant. Building stones, walling	17	0
	i. Calc Grits begin to predominate, base not seen. *Nautilus hexagonus*, *Ammonites-cordatus* group numerous, &c.	11	0
		28	0

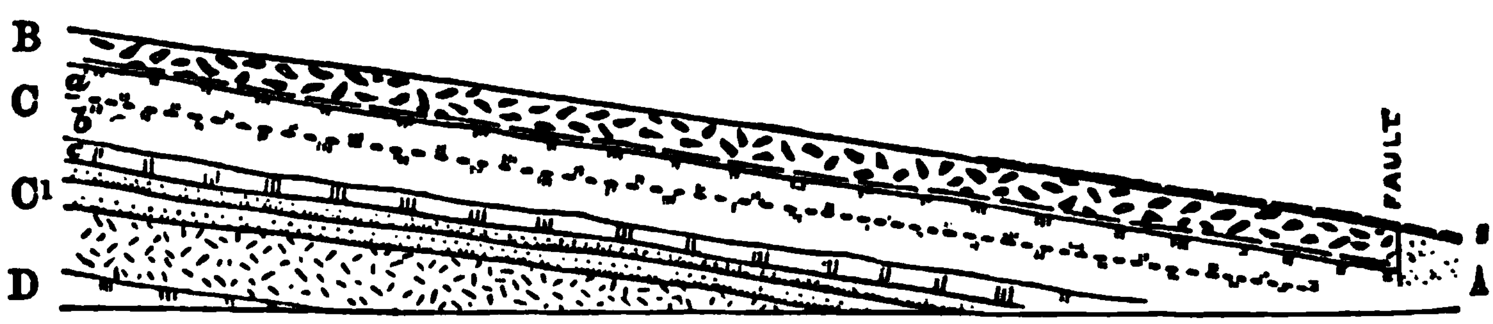
Reference should here be made to the sectional sequence on either side of Newtondale (p. 418), in order to fit this section to the beds below.

Throughout the whole series, from the *Trigonia*-beds well into the Coralline Oolite, ammonites generally referable to *A. plicatilis* are obtained; these sometimes attain enormous dimensions. Attention should be drawn to the abundance of corals in the base of

group *g*, unassociated with the Rag-urchins, which, with the Myacidæ and Anatinadæ seem, throughout the section, to be wanting.

Proceeding westwards along the margin of the Vale we obtain an excellent section in the Gorge of the Seven at Sinnington, which affords a good opportunity for comparison with that at Pickering, and is also useful as showing the exact relations of the Middle Calc Grit to the underlying and overlying limestones.

N. FIG. 16.—SINNINGTON SECTION. S.



Length 230 yards—actual dip about 5°.

Details of the beds.

			FT. IN.	FT. IN.
	a.	Soil, rainwash, and clay at the fault ...		4 0
	A.	Upper Calcareous Grit, consisting of (1) "Red beds" (*a* of the Pickering Section), (2) a band of hard blue rock, and (3) shaly sands, base not seen ... about		18 0
Upper Limestones, Middle Division of Pickering	B. 1.	Coral Rag, with plenty of *Cidaris florigemma* in the lower block, at the fault	13 0	
	2.	*Rhabdophyllia*-bed. The upper part is very full of small branches. This is the equivalent of the Coral shell-beds of other places...	2 3	15 3
	C.	CORALLINE OOLITE.		
	a.	Comparatively unfossiliferous limestone, the lower portion impure and dirty (*e* of the Pickering section) ...	11 0	
	b.	*Chemnitzia*-limestones. The great shell-bed at the top is charged with *Chemnitzia heddingtonensis*, *Nerinæa* sp., *Astarte ovata*, *Lucina globosa*, &c. Noted also *Ech. scutatus*. (*f* and part of *g* of Pickering section)	17 9	
	c.	Impure bluish limestones, with a line of scattered pisolite. (remainder of *g* of Pickering section)	6 0	34 9
	C1.	*Trigonia*-beds and Middle Grit (*h* and *i* of Pickering section plus the remainder of the Middle Calcareous Grit)... ...		34 0
	D.	Top of the Lower Limestone series ...		5 0
				111 0

As the quarried face is an old one, there are not those opportunities for obtaining fossils which the immense works at Pickering present. Other difficulties also exist in the way of a thorough investigation, such as the chance of breaking one's neck in endeavouring to examine the tempting arabesques presented by the weathered surface of the *Trigonia*-beds. Enough, however, may be seen to render it probable that they are extremely rich, whilst the upper portions of the Coralline Oolite appear less so. It is a circumstance worthy of note, that a spine of *Cidaris florigemma* was found in one of these *Trigonia*-beds, born, as it were, before its time.

Still continuing along the margin of the Vale, the next gorge is at the mouth of Hodgebeck, between Kirkby Moorside and Helmsley. At the ford on the old road, the *Trigonia*-beds form the floor of the river, which is generally dry except in rainy weather. The general sequence is not so well seen as at Sinnington and Pickering, and it is probable that the minor subdivisions are beginning to vary. The "black posts" for instance (*e* of the Pickering Section, C *a* of the Sinnington Section), are assuming greater importance. The base bed of this group, called by the workmen at Pickering "hilly and holey," is the cave line throughout the district, and it is on this line, about 35ft. above the ford, that the celebrated Kirkdale Cave occurs. It is well known that most of the rivers hereabouts "swallow," *i.e.*, run underground at certain points, as their predecessors seem to have done at a higher level, of which this cave now presents an example. The explanation is that such beds present a hummocky surface of hard impure limestone difficult of solution, with interspaces filled in by a soft limestone brash, which is readily disintegrated both chemically and mechanically by the action of running water. The origin of the peculiar rock called "black posts," as also of "throstler," though in some way connected with Coral, is not quite clear, the fossil evidence having been more or less melted up by some powerful action; but this subject is connected with the general lithology of the Coral Rag.

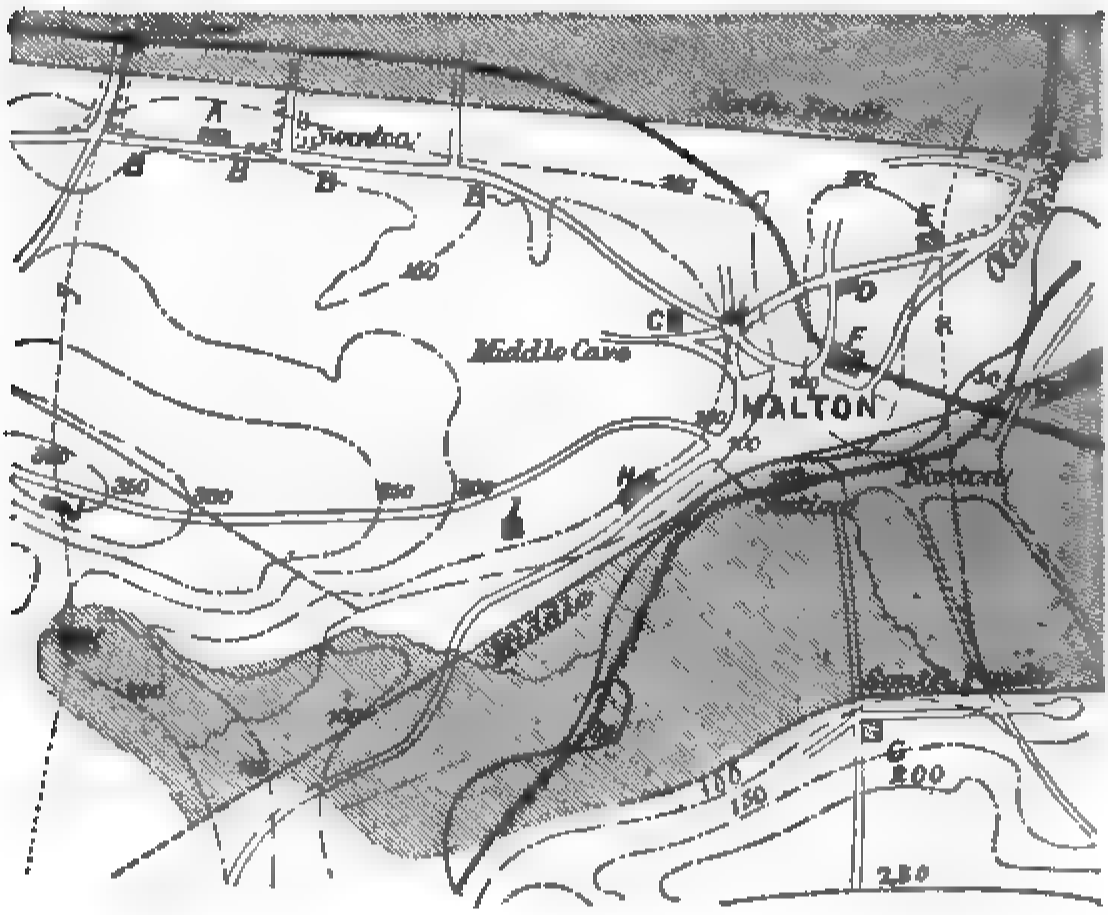
These types of the Coralline Oolite of the Tabular range may be traced to some extent into the neighbourhood of Helmsley, but before they reach the southern flank of the Hambleton massive, at Oswaldkirk, they are already changed; the *Trigonia*-beds have entirely disappeared, there is no Middle Grit, and no Lower Limestones as in any way separated from the Upper Limestones.

3. *Oolites of the Howardian Hills.* A portion of these may

belong to the Lower Limestones, but in the absence of absolute proof, they naturally fall into this subdivision. As the Oolites of Malton and the adjacent villages are largely developed, and have at times been extensively wrought, they may be taken as typical of the group. A little attention to topography is necessary, and the requisite information may be derived from an inspection of the accompanying Map.

FIG. 17.—CONTOUR MAP OF THE COUNTRY ROUND MALTON.

Scale 1 inch to a mile.



A. Limekiln Tavern quarry—Oolite.
BB. Quarries on the high side of the "Street"—Oolite.
C. Disused quarry—Gritty Limestones betwixt two oolites.
D. Cross-roads quarry, Peasy Hills—Oolite with capping of Rag.
E. Highfield Road, or Old Malton quarry—Oolite with capping of Rag.
F. Pye-pits quarry—Oolite with capping of Rag.
G. Whitewall quarry—Oolite and Rag.
H. Brows quarry—L. C. G. and Passage-beds. } according to the
I. Lyon's pit—L. C. G. and Passage-beds. } general belief.
J. Quarry on Hildenley Heights—Coral Rag.
K. Hildenley brickyard—Kimmeridge Clay.

N.B.—The 100ft. contour line which encloses the quarries D and F, does not cross the Middle Fault as shown above, see pp. 450 and 451.

The terminal promontory of the Howardians west of the river Derwent, is a mass of Corallian rock, chiefly Oolite, flanked on either side by Kimmeridge Clay. Along the northern escarpment the rock generally makes its appearance about the 100ft contour ; but in the town of Malton, just opposite the most easterly of the two bridges, the rock comes down in a steep face almost to the level of the river, here about 50 ft. above the sea. The principal Oolite quarries are, firstly, in the neighbourhood of Swinton—A, BB; secondly, in the peninsula between Malton and the village of Old Malton, D, E, F. Upon these latter there is a thin capping of Rag, so that the surface is formed by this class of rock, but the mass of the elevation consists of oolite, as is very plainly shown in the railway cutting and the three last-mentioned quarries. In the southern escarpment what is generally believed to be the Lower Calcareous Grit is worked at the Brows quarry H on the northern side of the Middle Fault.

In the neighbourhood of Swinton, the northern escarpment shows at least 60ft. of Oolite, and though the Passage-beds are not actually exposed in any section on this side within the limits of the Map, we may be certain that they underlie this Oolite. The sequence upwards is not so easy to trace, but there is no Coral Rag at the top. On the other hand, the Oolite in the eastern peninsula, between Malton and Old Malton, is clearly seen to immediately underlie the Coral Rag, whilst the descending sequence is more or less a matter for conjecture.

There are, therefore, two Oolites in the neighbourhood of Malton, occurring under different circumstances, and it is just possible that the one resting on the Passage-beds in the neighbourhood of Swinton may represent, to a certain extent, the Oolite of the Lower Limestones. Hitherto I have been unable to trace the stratigraphical relations of the two Oolites with certainty, but when they are closely examined a considerable difference is observed in their form and general character. Whether this is due to slight difference in age, or merely to lateral variation, remains yet to be proved. As the fossils of both have been long ago hopelessly mingled in collections, they are all placed in Column II. of the Table of Fossils, under the heading of Coralline Oolite. A comparison of the two following sections, one from each group of Oolite, may afford some insight into the nature of the differences :—

SECTION AT THE LIMEKILN TAVERN QUARRIES (A & B), SWINTON.

	Ft.	In.
Highside of road—		
Small-grained rubbly oolites in beds of 18-24 in., with brashy partings. *Ech. scutatus*, *P. fibrosus*, *Avicula ovalis*, *Myacites* in bad preservation	14	0
Lowside of road—		
Oolite and brash, sometimes false-bedded, with a few shells ...	8	0
Oolite very full of fossils, mostly small; *Cerithium muricatum*, c., *C. limæforme*, r., *Nerinœa Rœmeri*, c., *Cylindrites*, r., *P. fibrosus*, *P. lens*, *Lima gibbosa* (juv.), *Avicula ovalis* (fine), *Lucina globosa*, c., *Astarte depressa*, *Opis corallina* or *Phillipsi*, c., *Sowerbya triangularis*, c.	2	6
Oolites and brash, with beds of small shells; fauna nearly as above, but more scanty...	17	0
Hard oolitic limestones and brash with *Ech. scutatus* and *Cylindrites* numerous	5	6
Paste with Oolite in thick blocks, and wider brash partings, few fossils	9	0
	56	0

The beds dip about 5° at the low end of the bottom quarry, away from the great fault near the base of the escarpment, recover to about 2° nearer the road, and are nearly level in the top quarry. South of this the ground continues to rise, but affords little opportunity for estimating the further development of this series.

The numerous quarries, B, B, B, exhibit a class of rock similar to the upper beds of this quarry.

For the purpose of comparing the oolite east of Malton with the above, the quarry at D is selected.

SECTION AT THE CROSS-ROADS QUARRY, PEASY HILLS.

			Ft.	In.
CORALLINE	Coral Rag.	*a.* Soil. Brash, which is coralline, and contains spines of *Cidaris florigemma*	7	0
	OOLITE.	*b.* White oolite, not very fossiliferous	13	0
		c. Shelly oolites...	9	0
		c. Compact fine-grained oolites...	2	6
		In an adjoining quarry	6	6
			38	0

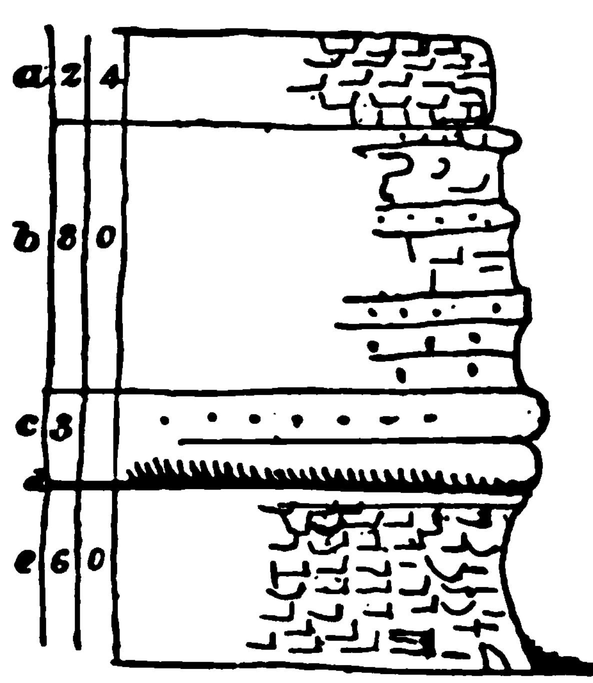
b. A clean white oolite, with very little paste. The ova are of medium size, regular, distinct, and usually free from shell-fragments; not many shells are to be seen. These oolites have a fauna somewhat approaching that of the Rag; and this may partly serve to account for the very mixed character of the fossils which come from the Malton district in an undoubtedly oolite matrix. *Phasianella striata* is plentiful towards the bottom. In an adjoining quarry this group has yielded some remarkable coniferous fruits.

c. These are the regular *Chemnitzia*-beds of the Coralline Oolite, and, in this quarry at least, contain the bulk of the fossils. The uppermost bed is a regular "rabbit-eye," *i.e.*, a mass of *Chemnitzia heddingtonensis* in transverse section—along with other shells. The principal shell-bed is thus at the top of the series, as seems frequently to be the case throughout the oolitic formations. This group is less oolitic than the overlying one; and the sedimentary impurities appear to be rather greater. The fossils most obvious on the weathered surfaces are *Chemnitzia heddingtonensis*, *Nerinæa Rœmeri*, *Astarte ovata*, *Lucina aliena*, *L. oculus*, Bl. & H.; the less frequent are *Ammonites plicatilis*, *Cerithium muricatum*, *Phasianella striata*, *Pecten lens*, *Lima læviuscula* (type form), *Cucullæa* (small sp.), *Cyprina corallina*, &c.

This quarry and the two adjoining ones have furnished a large proportion of the genuine Malton fossils. Their fauna is obviously different from that of the Swinton oolites, but resembles, in many respects, that of the Coralline Oolite of Pickering above the *Trigonia*-beds. If geologists should consider these differences to be due to mere lateral variations, no further explanation is required; but if the differences are allowed to be connected with the age of the beds, one might be disposed to refer the Swinton oolites to the Lower Limestones, those of East Malton to the Upper Limestones. Still some further confirmation of this view might be desirable, where no stratigraphical sequence has yet been traced.

The disused quarry (C) below Middlecave, where we have a series of "Passage-beds" sandwiched betwixt two oolites, seems to supply us with a clue.

FIG. 18.—PROFILE OF OLD QUARRY NEAR MIDDLECAVE.



a. Oolite, rubbly and fragmentary, but increasing on the dip. ? Upper Oolite.

b. Alternations of hard bands of oolitic Calc-Grit, with large-grained softish Oolites. *Ech. scutatus*.

c. Two hard bands of gritty large-grained Oolite, separated by a red sand of variable thickness. The lower portion of the second block is a mass of shells, often of large size, in a sort of Passage-bed matrix. A splendid list is made from here, including *A. plicatilis*, *Chemnitzia heddingtonensis*, *Lima læviuscula*, *Pecten intertextus*, *Avicula ovalis*, *Gervillia aviculoides*, *Trigonia Meriani*, *Trigonia* (clavellate), *Cypricardia isocardina*, and fragments of *Thamnastræa*, *Rhabdophyllia*, and numerous *Pholadomya*.

d. Brashy Line.

e. Oolite, at base of quarry, without fossils. ? Lower Oolite.

If we could persuade ourselves that these really are the oolites of the Upper and Lower Limestones respectively,* and that we have a faint repetition of the Middle Calc Grit in this section, it would be gratifying to such of us as may be desirous of establishing some correlation between the Corallian rocks of the Tabular and Howardian Hills. Unfortunately, in this case, the shell-bed, with *Trigoniæ*, is at the bottom instead of the top of the gritty series, and with some resemblance there is also considerable difference between this fauna and that of the Pickering *Trigonia*-beds. That the Oolite, *e*, has suffered some denudation previous to the deposition of the overlying beds, is almost certain, as a thorough change of conditions must have ensued before a rich shell-bed could be laid down on the top of an unfossiliferous oolite. True, it may be a purely local bed which is thus seen for a limited space to divide the Coralline Oolites of Malton, but this point, along with many others, must be left for the present.

Fossil Contents. The full fauna of the Coralline Oolite must be gathered from Column II. of the Table, but the following short list shows the common, or characteristic species. The quarries at Malton and Pickering have yielded the bulk of the fossils :—

CORALLINE OOLITE—COMMON OR CHARACTERISTIC FOSSILS.

	Belemnites abbreviatus, *Mill.*	Cucullæa corallina, *Damon.*
	Ammonites plicatilis, *Sow.*	Modiola subæquiplicata, *Goldf.*
v.c.	Chemnitzia heddingtonensis, *Sow.*	Trichites Plotii, *Lhwyd.*
	Cerithium muricatum, *Sow.*	Gervillia aviculoides, *Sow.*
	Nerinæa visurgis, *Auct.*	Lima læviuscula, *Sow.* (type.)
	„ Rœmeri, *Goldf.*	„ rigida, *Sow.*
	Myacites decurtatus, *Phil.*	„ elliptica, Whiteaves.
	„ recurvus, *Phil.*	Pecten lens, *Sow.*
	Pholadomya decemcostata, *Ræm.*	„ vimineus, *Sow.*
	„ parcicosta, *Ag.*	„ intertextus, *Ræm.*
	Quenstedtia lævigata, *Phil.*	„ fibrosus, *Sow.*
	Astarte ovata, *Smith.*	„ inæquicostatus, *Phil.*
	„ Duboisiana, *d'Orb.*	Anomia radiata, *Phil.*
v.c.	Lucina aliena, *Phil.*	Exogyra nana, *Sow.*
	„ ampliata, *Phil.*	Pygurus pentagonalis, *Phil.*
	Corbis lævis, *Sow.*	„ Hausmanni, *K. & D.*
	„ Buvignieri, *Desh.*	Pygaster umbrella, *Ag.*
	Trigonia Meriani, *Ag.*	Carpolithes conicus, *L. & H.*
v.c.	„ perlata, *Ag.*	

* This view was adopted with reservation in constructing Column XI. of the Table of Comparative Sections in the "Corallian Rocks of England:" it is certain that the thickness of the lower of the two Oolites was under-estimated on that occasion.—W. H. H.

Lithology. If we exclude such exceptional beds as the "black posts" of Pickering, the Coralline Oolite may be said to have two petrological types, the oolitic and the pasty, and its rocks are, for the most part, mixtures of these in varying proportions. Corals are usually rare. The oolitic granule is, as a rule, larger than that of the Lower Limestones. The pasty variety sometimes becomes very hard, and, in fact, appears as a dense creamy limestone, like that of group *f* at Pickering. This seems to have been the result of finely-ground coral mud, which has produced these calcareous pastes with oolitic grains, in some cases so closely cementing the shells and other organic fragments as to form rocks with a fracture almost like flint. The physical history of such beds seems to have been this:—The coral is being perpetually ground down to the finest powder, which is held suspended in the sea like ordinary sediment; but as it falls towards the bottom, it encounters an acid stratum of water, due to the quantity of carbonic acid generated by the decomposition of organic matter and the respiration of animals. This slightly attacks the calcareous sediment and forms the usual soluble bicarbonate, which is again precipitated as calcic carbonate amongst the interspaces of the slowly settling mud, thus cementing the whole into a mass of most compact rock, and gluing up all the shells.

From this type of rock, to a regular oolite with very little paste, there is every gradation. The Malton rocks, on the whole, contain the greater proportion of oolite.

It is difficult to avoid speculating upon the causes which have produced these granular rocks, so characteristic in this country of the Jurassic formations above the Lias. The evidence appears pretty conclusive that the structure is the result of original deposit, and that the subsequent modifications, though important, are yet of a subordinate character, being, in fact, nothing more than a sort of alteration, such as goes on in nearly all limestones. The connection of oolite with corals has long been noted, and since the physical features which accompany the modern formation of coral have been so elaborately described by Dana and others, we arrive at the conclusion that oolite is, for the most part, *granulated coral mud.** The finely-ground pulp, such as that producing the rock previously described, is associated with larger particles, which are

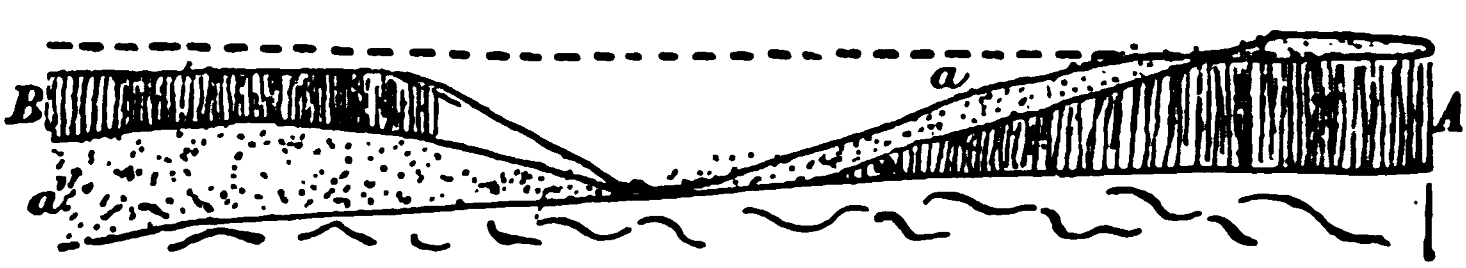
* Dana, on "Corals and Coral Islands," p. 152 *et seq.* There are, of course, other causes, unconnected with coral, which have produced an oolitic structure in rocks, though not perhaps on so extensive a scale.

the result of cementation through the alternate moistening and drying of the mud, assisted by the small quantity of soluble lime carbonate in the slightly acidulated fluid. This alternate wetting and drying between wind and water, adds a new layer to the surface of each grain, so that the process is one of granulation and concretion going on almost simultaneously. This takes place at the edge of the parent reef, and sometimes the reef itself is covered by similar drift accumulations which are cemented into a solid rock having an oolitic structure.

Some of the intercoralline beds of the Rag most probably represent these shore and drift accumulations, which have been preserved along with the coral whose partial destruction produced them. But the origin of the Coralline Oolite must have been different. This in Yorkshire always forms the basement rock, and therefore could never have been derived from the Coral, now forming the Rag, which grew upon it. There may be some plausibility in the view that Oolite and Rag were forming simultaneously in different localities, and that the oolite of one district is the *débris* of part of the Rag of another. Thus arises the question—Do any of the reefs which contributed to the formation of the Coralline Oolite of one part of the Yorkshire area exist as Coral Rag in another part?

The annexed hypothetical sketch is intended to show the probable action which went on at the time:—

FIG. 19.—FORMATION OF OOLITE.



A is a reef sufficiently high to be ground by the waves, and where coral mud and sand, *a*, are forming. Part of this is retained about the reef as beach and wind drift accumulation. But a portion is carried away just as sand or mud of any other kind, and is distributed over an area of deposit, a^1, which may be taken to represent a bank or lenticular mass in the course of formation. This would consist of just such a varying aggregate of paste and oolite as we have in the Coralline Oolite of Yorkshire. When the

bathymetrical and other conditions became suitable, a fresh reef representing the Coral Rag, *B*, grew upon the platform thus produced, and would in its turn be attacked by the waves. An indefinite distance separates *A* from *B*.

That something of this kind took place can hardly be doubted, and thus we arrive at the original proposition that a bed of oolite is the result of a pre-existing coral bank; but whether such coral bank was contemporary with any portion of the existing Coral Rag, or formed part of a slightly antecedent series, now wholly destroyed, is a question not easily answered. It seems to me that the several beds of which the Coralline Oolite itself is composed were laid down, and had in many cases been partly denuded before the Coral Rag, as now preserved to us, was commenced. The sudden change in the character of the rock, as shown in the quarries at Malton* and elsewhere, proves this.

Although it may be deduced from the above considerations that oolitic structure is largely due, in the first instance, to the formation of coral sand, the subsequent alteration of the oolitic granules is no doubt considerable. Some oolitic rocks are too soft for making thin sections; but, not to multiply examples, let us take a sound oolitic freestone as the type. This is one where the paste has become calcitic, and therefore each section of a granule stands out as a partially opaque disc in a crystalline ground mass. It is easy to perceive that there is much variety, but setting aside such interior fragments as sponge spicules, ground urchin spines, &c., which have formed centres, the bulk of the discs are without foreign matter as nuclei. They are of several shapes, but oval may be taken as the average. The interior consists of an inner circle of very fine granular matter, and an outer circle of concentric rings, having a radial or fibrous structure, and consisting partly of calcitic and partly of granular matter. Sometimes a granule has been made up by the coalescing of two or more, and sometimes, perhaps, this appearance is due to the primary nucleus having been a tri-radiate spicule. Very fine fragments of quartzose sand are also noticeable, usually outside the granule. Moreover, there are a number of discs, which either never had or have lost their outer rings. On the whole, there is

* See Section at the Cross-roads Quarry (D) p. 428.

nothing which militates against the view previously expressed as to the primary cause of the granulation, but, on the contrary, the changes are just what one would expect to take place in a rock whose chemical composition causes it to be so assailable by acids, and whose structure is expressly calculated to promote the circulation of fluids.

III. The Coral Rag (B).

The petrological contrast between the Coral Rag and the Coralline Oolite is more marked, perhaps, in some districts than in others, but in most cases an observer could hardly fail to be struck with it. Instead of the monotonous appearance of the oolite in those quarries where the shell-beds are poor, there is generally something very fascinating in a weathered face of Coral Rag, especially if it be formed of branching coral, loaded with shells, and spines of urchins, such as may be seen to perfection about Oswaldkirk, Slingsby, and other localities in the west. And even the more massive Thamnastræan Rag, with its undulating layers and bluff terminations, has its picturesque characters, though usually very barren ground for the fossil hunter. But the Rag is not made up entirely of coral: much is composed of fine coral mud, rarely oolitic, forming an intercoralline mixture, sometimes soft and slightly chalky,* sometimes hard and calcitic. This holds the bulk of the shells, which are often in a highly crystalline condition, and make splendid cabinet specimens, when they can be extracted without fracture—a rare occurrence. When oolitic structure is developed in this group of beds, the granules are usually large, irregularly pisolitic and lumpy. Great quantities of such rock, associated with masses of oysters, serve to swell out the bulk of the Coral Rag on Langton Wold and elsewhere, and in these higher beds *Cidaris florigemma* becomes much scarcer. It is probable, therefore, that the extra thickness of this subformation on Langton Wold is due to the preservation of beds which may have been denuded off in other districts.

The fauna differs materially from that of the Coralline Oolite, and this, no doubt, is partly due to difference in the conditions of deposit, but yet not wholly so. It should be remembered that

* The coral mud never forms "chalk."

there are in the Tabular Range three horizons where corals may be noted, viz:—

1. The Coral Rag, or subzone of *Cidaris florigemma*.

Limited Coral growths in lower formations,
2. The Coral band in the base of the Coralline Oolite at Pickering.
3. The Coral band at Hackness. Towards the base of the Lower Limestones—of some extent.

The first contains a rich and characteristic fauna, and is remarkable for the profusion of mammilated urchins, especially of *Cidaris florigemma*, and is of great extent: the two latter do not contain that fauna, and are destitute of the characteristic urchin.

Hence we are justified, to a certain extent, in assuming that the difference between *the* Coral Rag and these limited Coral growths of the underlying formations is due to the lapse of time, and to the changes wrought within the area by the accumulation of so much calcareous matter and its concomitants, and that the differences, therefore, between the Coral Rag and the Coralline Oolite are not due to the difference of a *facies* merely, but are also partly the results of a more advanced age. We can imagine that the fauna of the true *florigemma*-Rag was being slightly modified from the Upper Oxfordian forms in those very reefs whose destruction produced the bulk of the Coralline Oolite.

One difficulty remains to be encountered—*Cidaris florigemma* is made the "leit-fossil" of the Coral Rag, and yet it is not found in the Seamer-Brompton division of it. *Cidaris Smithii*, which appears to have a greater range in time, occurs together with many of the beautiful univalves characteristic of the *florigemma*-Rag elsewhere. For these reasons it is not separated, but there is just the possibility that this Rag of the Scarborough district should be placed in alignment with the Coral band in the base of the Coralline Oolite at Pickering.

Topographical Divisions of the Coral Rag.—1. *Rag without* Cidaris florigemma *of the Scarborough District.*—About 1½ mile N.W. of the quarry at Seamer, already described, are the Ayton quarries, which, being within an easy walk from Scarborough, have yielded collectors some very fine fossils. The junction of the Rag with the underlying oolite is well shown here. See sketch annexed.

Fig. 20.—Ayton Quarry (Scarborough Road.)

A. Loose Doggers and masses of *Thamnastræa concinna* in an ochreous marl; occasional branches of *Rhabdophyllia.*

B. The hard undulating masses of *A* seem to cushion themselves in the soft yielding brash of *B*, which is a very variable bed, being sometimes a hard flaggy shell limestone, as in the left of the section, and sometimes a soft brash, full of large *Phasianella* along with coral doggers and many other fossils, as may be gathered from the annexed sketch (Fig. 21), which was drawn strictly from nature. This bed is intercoralline in its character,

Fig. 21.—Portion of *B.* enlarged.

and belongs to the Rag, though the division between it and *C* is not always clear.

(*A* and *B*, constituting the Coral Rag, have a thickness of 8 or 9ft.)

C. Oolite with two shell-beds. *Nerinæa visurgis* and *Astarte Duboisiana* (fine). *Gervillia aviculoides.*

D. Oolites forming the base of the quarry. N.B.—As no more than 9 or 10 feet of oolite is visible in this quarry we may suppose, judging from its thickness in the Seamer Quarry (page 421), that only the uppermost beds are here exposed.

The working face of this group of quarries changes from year to year; the beds dip in rolls at a considerable angle towards the south, in which direction there were some very large pits, now filled in, where the Rag is much thicker than it is in the present quarry.

There are some good exposures in Ayton village, and at several points between that village and Brompton. At the latter, the old castle above the Keld (see Fig. 15, p. 422), had its foundations in this Rag, which, in this division, is nowhere capped by Upper Calcareous Grit, except in the outlier at Hackness. The actual continuity of this Rag at all points along the edge of the vale, cannot be proved. But it has been felt beneath the drift at the Cayton Waterworks, some distance to the east of Seamer, and it is at least probable that there is a continuous* belt as far west as Brompton.

2. *Florigemma-Rag of the Western Half of the Vale.* This topographical section of the Coral Rag is observed to extend along the inner rim, in a sweep from the quarry at Hagg House—1½ mile east of Pickering—to the neighbourhood of Slingsby—two miles east of Hovingham. There is, in this long semi-ellipse of beds, great variety, both as to development and thickness. The following is the section in the quarry above-mentioned where the Upper Limestones are again picked up after their loss near Brompton :—

QUARRY NEAR HAGG HOUSE, IN THE UPPER LIMESTONES.

Corresponding in Pickering Section.		FT.	IN.
a.	1. Upper Calcareous Grit, fossiliferous ...	6	0
b.	2. Argillaceous marly layers	2	0
d.	3. Dense ferruginous limestone in irregular lumps—the equivalent of the CORAL RAG	0	6
	4. Oolite—few fossils	6	6
e.	5. Dense and sometimes earthy limestones, with some oolitic granules—few fossils...	12	0
f.	6. *Chemnitzia*-limestones to base of quarry.		
		27	0

The equivalent of the Rag here contains a mass of fossils glued together in a dense ferruginous limestone with hard cores, indicative of its coral origin.. The following, in very bad condition, were

* *i.e.* Continuous, except for the breaks produced by more recent denudation, such as the present river gorges.

noted—*Natica*, *Nerinœa*, *Chemnitzia*, *Phasianella striata*, *Lima pectiniformis*, *Perna mytiloides*, *Arca quadrisulcata*, *Exogyra nana*, *Cidaris florigemma* (spines).

Here we seem to catch a glimpse of the edge of an original basin of deposit, and have, in bed 3, the thin end of a coral conglomerate, contemporary with the fine masses of coral observed *in situ* to the westward. In the principal quarries at Pickering, the Coral Rag makes a poor show (see Section p. 423), but on reaching the Gorge of the Seven we observe the more typical development (Section Fig. 16). Further west, in the neighbourhood of Kirkby Moorside, there is again some change in the type, and there are evidences of its blending, to a certain extent, with the dirty argillaceous limestones, known at Pickering as "Throstler," which there are sharply separated from the equivalents of the Coral Rag, and form part of the Supracoralline beds. On both sides of the synclinal at Helmsley, good exposures are to be obtained, but the upper part of the series there is frequently poor in coral, presenting the appearance of fine-grained siliceous limestones, such as may be seen in the quarry on the York Road.

At Oswaldkirk the Coral Rag attains its maximum thickness hereabouts towards the east end of the village, where there is a face of probably not less than 22 feet. In the Birch-House quarry it forms a bold precipice, weathering in large, swelling, rounded masses, which exhibit much *Thamnastrœa* and *Thecosmilia*, with profusion of spines of *Cidaris florigemma*, plenty of *Ostrea nana*, *Pecten vimineus*, &c. Throughout the village, wherever there is an exposure, we note the usual intercoralline beds, which tend to swell out the Rag. In the softer portions of such beds *Terebratula insignis* is not unfrequent. In some places the upper surface is so extremely uneven as to suggest the idea of unconformability with the succeeding formation; but this is no doubt due to the fissuring and shifting of a more recent date, as we find the hollows filled in with Upper Calcareous Grit in a tumbled and fragmentary condition, showing that it too was deposited and consolidated before such fissures were formed. In the Nunnington cutting, 1½ mile to the east, the Coral Rag, even including the Coral Shell-bed at the base, is barely 12 feet thick, but affords a good opportunity for collecting. On the whole, the Coral Rag of the Oswaldkirk district, especially about Nunnington, is rendered very interesting by

the quantity of *Thecosmilia* which it contains, and also by the profusion of spines of *Cidaris florigemma.* The varieties of Coral are perhaps more considerable than is generally the case in Yorkshire, as we frequently meet with *Montlivaltia dispar* and *Stylina tubulifera*, besides the more common reef-building forms: in these respects it differs much from the *Cidaris-Smithii* Rag of Seamer-Brompton, chiefly remarkable for *Thamnastræa concinna* and *Rhabdophyllia.*

A similar type for the most part prevails on the opposite side of the Gilling valley, as far as Slingsby, a village between Hovingham and Appleton. Thence, with the exception of a peculiar phase of Coral Rag at Hildenley, and a very thin cap on the promontory on the east side of Malton, there is no further exposure of this class of rock in the Howardian Hills west of the Derwent.

3. *Florigemma-Rag of Langton Wold.* The northern slope of this well-marked ridge, facing the Coralline peninsula of Malton (see Map, Fig. 17), contains several quarries, mostly in softish oolite, with sometimes a moderate development of Rag at the top. The quarry at Whitewall—*G* of the Map—is of this character. The Rag there is tolerably fossiliferous, and is noted for fine specimens of *Terebratula insignis.* The crest of the hill is kept entirely by Coral Rag, which falls over to the southward with a sharp dip, forming a ridge, including the outlier of North Grimston, of nearly five miles in length. The thickness varies, but where the dip and slope are to the south, the Rag seems to pass under the supra-coralline formations, without loss of its upper beds. At North Grimston, the hard Rag and underlying urchin series are at least 60 ft. thick, and it is not improbable that something like this development may obtain throughout a considerable part of the southern slope of Langton Wold. The quarries on the north side show nothing like this thickness of Rag, nor is there anything which could represent the marly paste with oolite so full of mamillated urchins. It is evident, therefore, that there is much to clear up before we can arrive at a correct understanding of the puzzling geology of the Langton-Grimston ridge.

At the village of North Grimston this ridge is cut through by a transverse valley, thus forming, in conjunction with the escarpment here facing the north, that remarkable salient, North-Grimston Hill. In this way, starting from the village itself, we may

trace a continuous sequence from a low position in the Lower Calcareous Grit up into the Kimmeridge Clay of Burdale, as follows:—

NORTH GRIMSTON TO BURDALE.

		FT.	IN.
Supra-coralline.	1. Cement-stone, or "Lias," maximum proved (at quarry)	36	0
Coral Rag.	2. Coral Rag, "North-Grimston limestone," about	40	0
	3. Marly Oolites, with an occasional coral band or hard limestone, the mamillated-Urchin series, say...	25	0
Coralline Oolite and Passage-beds.	4. Drab-coloured marly oolites, becoming very earthy towards the base: full of *Echinobrissus scutatus*, the equivalent of the Coralline Oolite of other districts, say	30	0
	4[1]. Passage beds about	6	0
L.C.G.	5. Lower Calcareous Grit down to bed of beck...	62	0
	Total thickness of beds in the escarpment ...	163	0

The best place for studying the development of the Urchin-beds is at the west end of the lower quarry on the south side of the Wharram road, where the lime-kilns are built in some soft drab-coloured marly oolites, said to be very full of *Echinobrissus scutatus*. The latter probably represent the upper portion of group 4. But between these and the limestone No. 2 are some 20-25 feet of beds the representatives of group 3. They are seen to consist of flattened buff-coloured granules in a buff or drab-coloured marl; and sometimes the marl or paste is devoid, or nearly so, of any granules. They are divided occasionally by beds of hard compact limestone, having partially the features of the Rag, and containing a few corals, many spines of *Cidaris florigemma*, and small muricated univalves: one of these hard bands, towards the top of the series, has a thickness of 2ft. 6in., and exhibits a fine arabesque of shells such as are usually associated with a Rag-fauna. Throughout the series, and especially towards the upper part, a profusion of the spines of urchins may be noted, and the tests of many are from time to time discovered. *Pseudodiadema hemisphærica* is especially abundant, and may be called the North-Grimston Urchin *par excellence*. *Cidaris Smithii*, *Cid. florigemma*, *Hemicidaris intermedia* also occur, the latter frequently. *Collyrites bicordatus* and *Pygaster umbrella* are also quoted from here; and *Echinobrissus*

scutatus, which swarms in the lower beds, cannot fail to put in an appearance.

In the quarries the hard Rag (2 of the above section), presents two phases. Without detailing the beds, the following is a description, taken principally from the upper quarry, in descending order :—

	FT.	IN.
a. Buff-coloured limestones with yellowish markings; beds of white stone, seldom hard and crystalline like the series below. Indications of corals moderate: flints rare. Spines of *Cidaris florigemma* less plentiful. *C. Smithii* and *Hemicidaris intermedia* numerous. Beds less shelly than lower series, but contain a fair assemblage of some of the Rag-fossils, *Nerinæa*, *Littorina pulcherrima*, *Opis*, &c., along with *Pentacrinites* and *Apiocrinus* ... ... about	20	0
b. Soft yellowish brash, with *Ammonites varicostatus* ...	0	4
c. White sparry and compact limestones in strong blocks, which become largely charged with flint, especially about 6 ft. above the base of the series. Beds full of fossils: fauna megalomorphic	17	0
d. Urchin series.		
	37	4

Some of the beds are very rich in shells; but these are frequently so glued into the general mass of the limestone as to be difficult of extraction. Nevertheless a fine body of fossils, without enumerating the teeth of Reptilia, have been proved here. The lowest portion of *c* consists of alternations of hard and soft Rag and has a thickness of about 6ft.: this is moderately shelly, and contains numerous spines of *Cidaris florigemma.* Above this occurs the great shell-bed, about 3ft. thick; it is a mass of the most splendid fossils, all of them the finest and largest of their kind. The small univalves so frequent in other parts of the Rag are not common here, the fauna being essentially megalomorphic. *Lima læviuscula* (var.) is the prevailing shell. The species of corals are those found elsewhere in Yorkshire; but *Thecosmilia* and *Rhabdophyllia* are most frequent.

The section at North Grimston represents the fullest phase of the Rag or Upper Corallian, just as the section at Pickering represents the finest development of the Coralline Oolite of the Tabular Range. The contrast between the two sub-formations may be said to reach its maximum at these two points respectively. The fauna of the Oolite of Malton seems to be intermediate between the two.

Subjoined is a restricted list of the fossils of the Coral Rag, or Upper Corallian of the Langton-Grimston district :—

Ammonites varicostatus, *Buckl.* (var. of A. plicatilis.)
Ammonites vertebralis, *Sow.* (var. cawtonensis.)
Purpuroidea nodulata, *Y. & B.*
Natica globosa, *Ræm.*
„ clytia, *d'Orb.*
c. Chemnitzia, var. of heddingtonensis, *Sow.*
Nerinæa Rœmeri, *Goldf.*
Littorina pulcherrima, *Dollf.*
c. „ muricata, *Sow.*
Neritopsis Guerrei, *Héb. & Desl.*
Pleurotomaria reticulata, *Sow.*
Trochotoma tornata, *Phil.* (T. discoidea, *Buvig.*)
v. c. Ostrea duriuscula, *Phil.*
v. c. Exogyra nana, *Sow.*
„ sp.
Ostrea gregaria, *Sow.*
c. Anomia radiata, *Phil.*
v. c. Pecten vimineus, *Sow.*
„ inæquicostatus, *Phil.*
„ intertextus, *Röm.*
Pecten lens, *Sow.*
c. Hinnites corallina, *sp. n.*
v. c. Lima læviuscula, *Sow.* (N.-Grimston variety.)
c. Lima rigida, *Sow.*
v. c. „ pectiniformis, *Schlot.* / rudis, *Sow.*
„ sp. (*cf.* elliptica. *Whit.*)
c. Trichites Plotii, *Lhwyd.*
Mytilus ungulatus, *Y. & B.*
c. Arca quadrisulcata, *Sow.*
„ pectinata, *Phil.*
Cucullæa elongata, *Phil.*
v. c. Astarte ovata, *Smith* (attaining a great size.)
c. „ rhomboidalis, *Phil.*
Opis virdunensis, *Buvig.*
„ lunulata, *Röm.*
„ Phillipsi, *Morr.*, or corallina, *Damon.*
Terebratula insignis, *Schüb.*
c. Cidaris florigemma, *Phil.*
c. „ Smithii, *Wright.*
c. Hemicidaris intermedia, *Flem.*
v. c. Pseudodiadema hemisphærica, *Ag.*
c. Pygaster umbrella, *Ag.*
Echinobrissus scutatus, *Lamk.*
Pentacrinites, sp.
Apiocrinus, sp.

The Lithology of this group is more varied than that of the preceding ones. Much depends upon the nature of the coral; whether it is branching, like *Thecosmilia* and *Rhabdophyllia*, or compact like *Thamnastræa* or *Isastræa*. Great changes have taken place during the process of mineralization: much of what was once coral is now calcareous spar, partly replacing the original structure, and partly filling large cavities with calcite. The upper beds in many places are also greatly silicified, and this silicification occurs in many ways, not being confined to the purely coralline portions of the Rag, but extending to the compact limestones and intercoralline beds which tend to swell it out.

In close proximity to the clays and grits of the Supracoralline beds, as at Pickering, the Coral Rag contains bunches of crystal-

line quartz (rock crystal), which have been deposited in cavities of the limestone. There is a tendency, however, in many parts of the Rag to various forms of silicification, altogether irrespective of proximity to the overlying beds, as may be well studied in the Langton-Grimston Rag. The first thing noticeable is the tendency to "beekization" in the oyster shells. A specimen of *Ostrea duriuscula* is exhibited, showing the external layer "beekized": the middle layer of the shell has been eaten away, leaving a number of siliceous pillars supporting the outer layer like the roof of a cavern. The small *Exogyra* which swarms here, and the Oysters generally are more or less silicified.

The hard Rag of this district is usually very siliceous. A fragment from one of the North Grimston shell-beds shows it very clearly. The fragments of the little *Exogyra* are seen to be developing specs of botryoidal chalcedony. A thin section placed under the microscope reveals some very interesting phenomena, which may afford a clue to the source of so much silica. Besides a number of spicular forms of various shapes, the slice is observed to be crowded with a quantity of renuline bodies, nearly all of the same shape and size. These are much smaller than the ordinary oolitic granules, and much more uniform in their appearance, otherwise their oval shape might lead to their being confounded with very fine grained oolite. If a portion of the rock is treated with very dilute acid, many of these renuline bodies, being siliceous, can be detached from the matrix. Similar bodies have been noticed and described by Mr. Sorby, and more recently by Mr. Blake, who was disposed to refer them to Foraminifera. But Mr. Sollas' view seems the most in accordance with the facts as here observed, viz., that they are the globo-stellate spicules of a lithistid sponge.* If, then, these renuline bodies really were in the first instance ovate spicules, such as those which form the interlayer of a species like the existing *Geodia arabica*, the acerate and anchoring spicules and other parts must have been equally abundant, affording a copious supply of organic silica, which has been one source of the chalcedonic matter so largely pervading portions of the North Grimston hard Rag. *Cliona* also may have contributed to swell the amount of silica secreted

* For an account of "globo-stellates," and of the changes they undergo through the action of caustic potash, cf. Sollas, in the Ann. and Mag. of Nat. Hist., 1877, p. 292.

and left behind by spongious organisms, and which has run about the rock, just in proportion as the original organic silica yielded to the action of solvents. It is interesting, for instance, to notice how completely the phragmacone of the large Belemnite in this specimen of hard Rag is chalcedonized at the tip, whilst the central portion consists of calcite crystals surrounding a conical cavity. It is not very difficult, in this case, to perceive how the silica got at the tip, for a thin layer of chalcedony lines the interior cavity all the way down, partly occupying the position of the "pen" of the original shell. Thus, we again see that decay of organic matter, and facility of infiltration, tend to determine a deposit of chalcedony.

Another specimen from North Grimston shows how chalcedony, in large mamillary masses, occurs in connection with coral. It is taken from a junction of *Thamnastræa* with indurated intercoralline matter. A slice cut at the junction in the neighbourhood of a bore-hole serves to show the stars of the *Astræa*, which are becoming faint, except at the edge, and disappear entirely where the chalcedony becomes opaque and milky; showing that the inner portion was, in all probability, deposited in a cavity, whilst the outer and more flinty looking portion is the result of displacement.*

Finally, we pass to flint, and of this there are great masses both parallel with the bedding, and lining the diagonal fissures. This may be seen in those quarries where there is a sharp dip to the south, which has caused a fracture of the beds and consequent gaping; whilst, singularly enough, it does not seem to be produced in that portion of North Grimston Hill where the beds are level. Flint can only be viewed as chalcedony of a peculiar character, but of infinite variety, according to the bed in which it occurs. The original character and markings of the limestone seem to be fairly preserved in these flints, as may be seen by comparing the specimen containing a section of an urchin with the ordinary hard intercoralline portions of the Rag. The shell fragments, spines, test, matrix, and everything are silicified. The spines of urchins generally hold out to the last. There seems,

* There is a peculiar structure observable inside this coral, something like the *Aulopera dichotoma*, Goldf. (Tab. 65, figs. 1 and 2), *Alecto corallina*, d'Orb.; see also *Talpina*—Morris' Catalogue.

therefore, no reason for doubting that these flints are the result of the silicification of the intercoralline portions of the Coral Rag, though what determined the action in this particular case is not very obvious.

IV. The Supracoralline Beds (*A*).

Reference should be made to the sections at Pickering and North Grimston (pp. 423, 440), in order to understand the development of this group, which, on the whole, is not a satisfactory one. The beds are there, and often of considerable thickness, but they are not good historians of the period, which was revolutionary, and one of decadence. Hence the fossils are few, and badly preserved. Passing over the Scarborough district, where there is but a trace at Hackness, we first meet with beds of this group in the Hagg House quarry (p. 437). The Coral Rag is there overlaid by an argillaceous marl, 2 ft. thick, on which rests the Upper Calcareous Grit. At Pickering 17 ft. of these kind of beds intervene between the Rag and the Upper Calcareous Grit. The "Throstler" is a peculiar argillo-calcareous stone, of very unequal development, which first appears at Pickering, and assumes considerable importance towards Kirkby Moorside, where it seems to contain occasionally a sort of revival of Coral Rag. Certainly, in this region, there is a considerable mass of argillo-calcareous rock, which has hardly yielded a recognisable fossil, interposed between the Coral Rag and Upper Calcareous Grit. From Kirkby, westwards, all the way round by Helmsley to Oswaldkirk, the Supracoralline Beds are not less than 30 ft. thick, and form an important feature in the country; the lower portions are still argillaceous, but reddish cherty grits prevail towards the top. These are sufficiently fossiliferous in places, especially at Pickering, but the forms are difficult to determine. In the Kirkdale cutting, south-west of Kirkby Moorside, there is a section, now grassed over, about 16 ft. deep. Towards the top occur red sandy clays, with calcareous discs and nodules. Ammonites, some in a tilted position, were found at the base of this. The remainder of the cutting was seen to consist of hard blue rock, and buff-coloured calc grits, full of dichotomizing forms. Several ammonites of considerable size were found during the progress of

the railway (see Table), the forms having a strong Lower Kimmeridge aspect. All about Helmsley there is a great quantity of Upper Calcareous Grit, and in the valley of the Rye below the town, it forms a little cliff of extremely red cherty rock, on which Rye House is built. In the Nunnington cutting again, east of Oswaldkirk, there is a section of these beds 30 ft. thick, dipping about 5° N.N.E., and apparently right under the Kimmeridge Clay, which succeeds on the dip slope.

Not a trace of Upper Calcareous Grit is to be seen in the Howardian Hills, west of the Derwent, but the "Throstler" has been proved on the dip slope at Hildenley, and is succeeded by the Kimmeridge Clay of Sir Charles Strickland's brickyard,* whence a fine series of Lower Kimmeridge fossils have been obtained. East of the Derwent, the Supracoralline beds are very copiously developed on the south side of the Langton-Grimston ridge, usually in the argillo-calcareous form. Hence it is probable that the Cement-stone of the North Grimston "lias" quarry represents the Throstler rather than the Upper Calcareous Grit of Pickering. The fossils, however, are pretty much the same in both. These beds dip south towards the Chalk escarpment, in the direction of Lord Middleton's brickyard (Kimmeridge Clay), but their full thickness (36 ft., proved in the quarry) is unknown. A large portion of the country between the Langton-Grimston slope and the Chalk escarpment (see explanation to sketch map, Plate iii.) is occupied by these Supracoralline Beds, and in some places their boundary is not easy to trace, so that I cannot well say how far they extend, though at Rowmire Spring beds of this character may be seen faulted against the Lower Calcareous Grit.

Between the village of Langton and the Grand Stand, are some speckled grits—like the Passage-bed stone—which contain a few phantom fossils. If the determination of such wretched specimens can be relied upon, we have *Belemnites nitidus* and *Ammonites serratus*, pointing to the Upper Calcareous Grit, which, in certain places, south of the Coral Rag ridge, probably overlies the more argillaceous portion of supracoralline rock, some of which might possibly be mistaken for Kimmeridge Clay.†

* See introduction to part ii., p. 360.

† Since the above account of the Supracoralline Beds in Yorkshire was written, my attention has been called by Mr. Fox Strangways to a singular fragment of Cement-stone rock of very considerable thickness beyond the

Subjoined is a list of some of the common or characteristic fossils of the Supracoralline Beds :—

Belemnites nitidus, *Dollf.*	Gryphæa subgibbosa, *Bl. & H.*
„ abbreviatus, *Mill.* var. *c.*	Avicula ovalis, *Phil.*, var. obliqua.
Ammonites alternans, *V. Buch.*	Pecten Midas, *d'Orb.*
„ biplex-varicostatus } *	Lucina aspera, *Buvig.*
„ decipiens, *Sow.* } *	„ substriata, *Rœm.*
„ Berryeri, *Lesour.*	Thracia depressa, *Sow.*
Ostrea bullata, *Sow.*	Pleuromya, Myacites, Goniomya, numerous.

V. Stratigraphy and Physiography.

Before proceeding to a general summary founded upon the previous details, a brief notice of the peculiar stratigraphical features of the country surrounding the Vale of Pickering is absolutely necessary. Until the mysteries which lie beneath that Kimmeridgian gulf are solved, it cannot be said that we have at all a full knowledge of the development of Corallian rocks in Yorkshire. These, as will be remembered, form three-fourths of the circuit round the Vale (see sketch map, Plate iii) and, as the cretaceous escarpment constitutes the fourth part, at a higher level it might be supposed that a sort of continuation of the Howardian Hills existed under a wreath of chalk, though, in point of fact, such is not the case, as the Corallian rocks of North Grim-

limits of the sketch map, containing the characteristic Cephalopoda. This has been let down by the great double fault, which produces the Gilling-Coxwold gap, and thus divides the Hambleton from the Howardian Hills. The most curious fact is that, instead of resembling the Upper Calcareous Grit of Oswaldkirk, only a few miles to the eastward, it has many of the features of the North Grimston Cement-stone, quite at the other end of the Howardian Hills. This fragment is seen to rest upon Coral Rag at Snape Hill, and is there faulted against the Lias; it is probably the rock referred to by Phillips, when he speaks of the Upper Calcareous Grit being found in the neighbourhood of Kilburn.

* Such names are admittedly only makeshifts, in order to register the occurrence of numerous ammonites, belonging to the group *Perisphinctes* which are too badly preserved to admit of very close definition. Many of these ill-preserved forms and fragments have a strange resemblance to some of the figures of *Perisphinctes* in the "Mèmoires de la Société Paléontologique Suisse," from the zone of *Ammonites tenuilobatus* in Argau, and from the zone of *A. acanthicus* in Switzerland and Savoy. A trifurcation of the rib across the back is not an uncommon feature. The zone of *A. acanthicus* in the Alps is deemed the base of the Kimmeridgian of that region.—Cf. Morris, in "Geological Magazine," 1878 (Aug.), p. 354.

ston are faulted out of sight in Nine-spring Dale just before the Chalk escarpment is reached.

This very singular resemblance to an atoll has given rise to the idea that the girdle of Corallian Rocks might possibly be the remains of an elliptical coral reef, with a central hollow, representing the lagoon, now filled in with Kimmeridge Clay. In that most delightful of geological works, " The Primæval World of Switzerland," Professor Heer, after pointing out the fringing reefs that cling to the west side of the Black Forest shore, proceeds to show us the lagoons and atolls of the Jurassic period in northern Switzerland.* One of these atolls has a length of 24 miles, and its lagoon has the form of a long, narrow ellipse. The great coral banks of Mont Terrible, the classic ground of the Lethæa Bruntrutana, form the N.W. part of the rim of this old Swiss lagoon. It is not easy to gather from Professor Heer's statements, what is the nature of the deposits within the lagoon, and details both stratigraphical and otherwise, are altogether wanting.

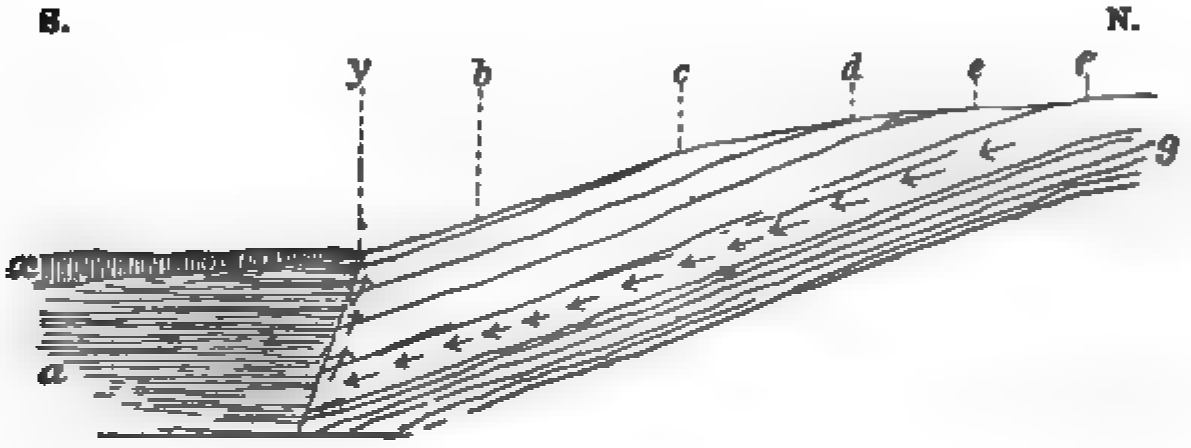
Hence, even if we had no other indications, it would be dangerous to infer merely from Swiss analogies that the Vale of Pickering represented a lagoon of the Jurassic sea; but when we come to stratigraphical considerations, an explanation of existing phenomena, more in accordance with the accepted geological views is presented to us. We are, in fact, tempted towards the conclusion that this apparent elliptical arrangement is due to a series of faults and folds, whose extreme synclinal depression may be traced in the rocks at Helmsley. The mean strike on either side of this synclinal meets at an angle towards the west, and the result is a deep inlet or bay, the mouth of which is closed by the Chalk escarpment, and in a less degree by the Drift of the coast.

As the Vale of Pickering is much covered by superficial deposits attaining a depth, in some places, of 70 ft., it is not easy to ascertain the position of all the faults which may lie concealed beneath its surface; but there is one longitudinal fault of great importance which inclines to the northern side, and probably passes out to sea not far South of Filey Point. The Upper Limestones of the Tabular Hills are seen to be cut off suddenly by this fault at Brompton, and the apposition of these porous rocks with the Kimmeridge Clay at the edge of the vale is there marked by the series

* Heer's " Primæval World of Switzerland," (Heywood), Vol. i., p. 121.

of springs which form the Keld, or headwater of Brompton Beck. (see Fig. 15, p. 422). At Wydale quarry, a mile further west, many feet above the edge of the Vale, the same fault brings the Kimmeridge Clay in juxtaposition with the Lower Limestones. Thence it has been traced for a considerable distance to the westwards. The disappearance of the Limestones at Pickering is probably due to the same or a parallel fault. A little west of the town and about the 100ft. contour, at the junction of the last slopes of the Tabular Hills with the vale, the Costa flows, a ready-made river of some magnitude, from the pool at Keld Head. Again, we seem to perceive the effects of the juxtaposition of a wall of Kimmeridge, or valley Clay, against the porous Corallian Beds, whose waters, instead of filling Newtondale Beck, leak through a hundred crevices, and thus form an underground stream, which is unearthed at this spot. On the whole, the stratigraphy of the Tabular Hills is simple; the general dip of the rocks is to the south, and, as previously explained, at an angle which causes the beds which are highest in a geological sense, to occupy the most depressed positions at the edge of the vale. These are suddenly snapped off, and the whole system jammed against a mass of clay, as indicated below.

FIG. 22.—RELATION OF THE TABULAR HILLS TO THE VALE OF PICKERING.



a. Kimmeridge Clay.
b. Upper Calcareous Grit, sometimes with a cap of Kimmeridge Clay, &c.
c. Upper Limestones.
d. Middle Calc Grit.
e. Lower Limestones.
f. Lower Calc Grit.
g. Oxford Clay.
x. Superficial Deposits of the Vale of Pickering—chiefly clays.
y. Keld Head—Source of the river Costa.

All attempts to reach the rock by boring have failed; and this

should be borne in mind, as it shows that the hade of the fault must be very steep, or that there is something unusual in the sudden and total disappearance of the rock at the edge of the vale.

The stratigraphy of the Howardians, though a smaller mass, is far more complex. This range forms the opposite flank of the Vale,* and the normal dip of the beds being N.N.E., we should expect that this dip would prevail at the junction of the rock with the clays, as the opposite or southerly dip does generally throughout the Tabular Range. Such, however, is not always the case, and it is evident that the area is one whose stratigraphy is extremely complicated. Some clue to the working out of the problem may perhaps be furnished by a study of the system of faults at Malton.

The natural positions in the vicinity of this town (see Contour Map, Fig. 17, p. 426†), due entirely to geological, or rather to stratigraphical causes, have long marked it out as a place of importance. The western Howardians may be said to terminate here in a tongue of limestone rock, which projects into a level expanse of Kimmeridge Clay. The tip of this promontory is cut through by the Derwent below Old Malton, and a little further back by a dry valley, possibly some previous waterway, so that a section of the Corallian area is completely insulated, and has the river Derwent as a natural ditch on the south-east. The Romans were not long in finding out the advantages of such a position as the partially preserved Roman Camp will testify, and although archæologists are not absolutely agreed that the name of the station was *Camulodunum*, it is evident from the immense quantities of Roman coins found here, that the locality was much frequented by them.

These peculiarities are due to the extensive system of faults prevailing here, and in order to show this more clearly, a section across the Coralline peninsula is appended. (*See opposite page*).

* See Proc. Geol. Assoc., Vol. iii., p. 285, "Yorkshire Oolites," Part 1.

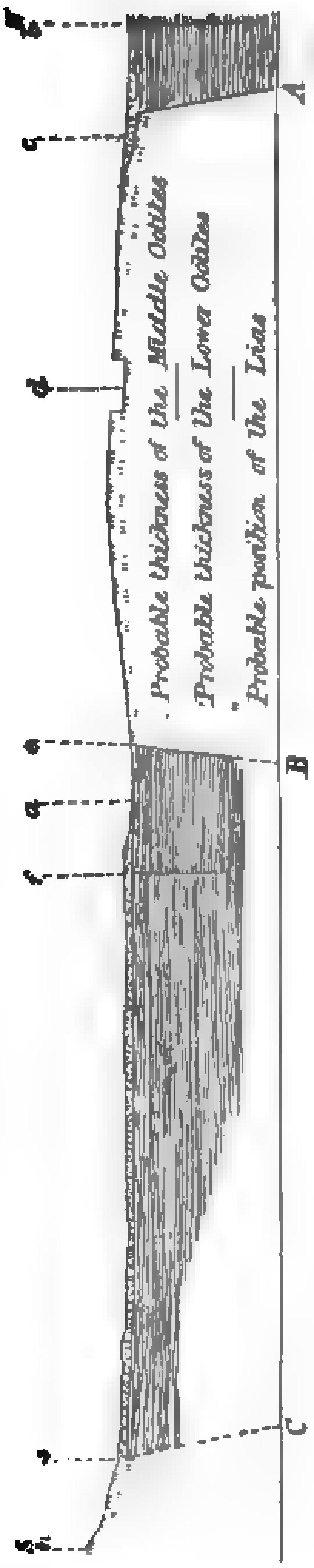
† The following additional explanations are necessary :—

x. Line of section from Malton Fields to Whitewall (Fig. 23).

y. Portion of section passing through Hildenley Heights (Fig. 25).

N.B.—The western prolongations of the Middle and Southern Faults are only laid down approximately. The extent of the tongue of Kimmeridge Clay in this direction is likewise at present undefined.

FIG. 23.—OLD MALTON FIELDS TO HIGHBECK SPRING, NEAR WHITEWALL.
Distance—Two miles one furlong. Horizontal scale, 3 in. to 1 mile; vertical scale, 6 in. to 1 mile.



A. Old Malton, or north fault.
B. Norton, or middle fault.
C. Whitewall, or south fault.

a. Position of the river Derwent at Malton; bank 50ft. above O. D. at railway bridge.

b. Boring in Old Malton fields through Superficial Beds and Blue Clay to a depth of 468ft. 70ft. above O. D. at surface.

c. Well in Westgate lane, Old Malton (1,000 ft. south of *b*), reaches oolite rock at 28ft.

d. Highfield-road quarry (100ft. contour passes over the top) in oolite and Rag—E. of map, fig. 17. Beds dip slightly to the N E.

e. The Lady's Spring: on the line of fault proved at Russell's brewery—Malton water supply.

f. Unsuccessful boring through about 400ft. of Superficial Beds and Blue Clay, near St. Nicholas Church, Norton.

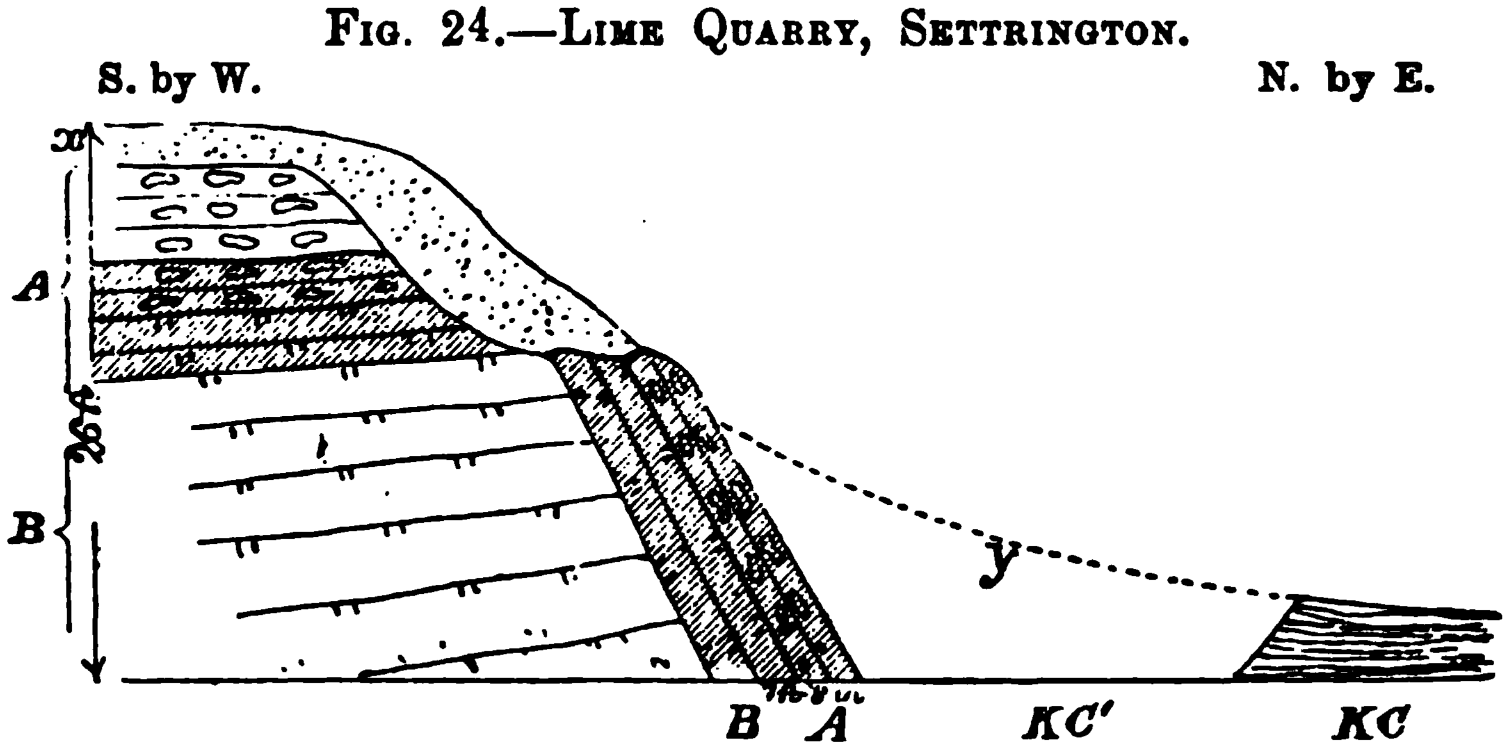
g. Base of escarpment near Whitewall-corner, about the 100 feet contour. Line of fault indicated by Highbeck Spring.

h. Limestone quarries—Coral Rag upon Coralline Oolite: dip northerly—up to the 150ft. contour in Langton Wold ridge.

It must be admitted that the thickness of the superficial deposits in the lower, or vale portions of this section tend to obscure its reading, the more so that they consist partly of clays themselves; still there is difficulty in avoiding the conclusion that along this line we cross three faults, or folds so sharp as

to have the effect of faults. At the north end the fault, or whatever it may be, can clearly be fixed between *b* and *c*, a distance of 1,000 feet. The rods, after passing through 17 feet of surface matter, continued in "hard dry clay with white specs" to 150 feet, and thence through variable clays with hard bands to a depth of 468 feet, without ever touching the Oolite Rock, which was the object of the search, though this was found within 28 feet at *c*. Here we enter the Coralline peninsula, rather under a mile in width on this line. On the plateau the beds are nearly level, with slight north-easterly dips on the north side, and east south-easterly dips on the south side. The Oolite Rock comes to a sudden termination at the Lady's Spring, where a copious supply of pure water oozes up on a level with the river. The evidence as to the rock being really lost, and not merely covered up by superficial clay, may be found in numerous borings in or near Norton, one of which is said to have gone through 400 feet of Blue Clay without touching the rock, although they started close to it. Between *f* and *g* the surface is pretty level, but with a gradual rise towards the foot of Langton Wold ridge, where, in the sharp rise at Whitewall-corner, we once more find the Corallian limestones. That we are fully justified in placing a fault at the foot of this escarpment, may be gathered from an actual exposure two or three miles to the eastward, where, at the lime-quarry near Settrington, the following section may be observed :—

FIG. 24.—LIME QUARRY, SETTRINGTON.



A. Coral Rag—The position of *A* should be rather higher up.
B. Coralline Oolite.
K. C. Kimmeridge Clay.
K. C'. Kimmeridge Clay removed.
x. Surface rubble, &c.
y. Original slope of surface.

Owing to the removal of the soil and clay at the point where the railway to Driffield first strikes the Langton ridge, a state of things was disclosed which was of material benefit to the contractor, viz., that the hard rock which was supposed to pass under the clay of the vale broke off short, as indicated in Fig. 24. It will be observed that the portion of rock which has fallen over into the fault or unconformity, can be defined with absolute certainty, as it happens to be that piece which forms the junction between the Coral Rag and Coralline Oolite. This curious wall of rock may now be traced for some distance westwards from the quarry face; whilst in the opposite direction, where the line ultimately begins to cut through the Corallian rocks, this piece, which is very hard and much discoloured from contact with the clay, may actually be seen to stand out like a trap dyke in those portions of the cutting which are not ballasted. Ammonites and oysters are said to have been found in the Clay, which is blue and does not appear remanié.*

The evidence as to the Blue Clay of Section, Fig. 23, being Kimmeridge Clay, is briefly as follows† :—

PARTICULARS OF THE BORING AT OLD MALTON (*b* Fig. 23).

FEET.		
1— 17.	Superficial Beds; sand, clay, gravel.	
17—150.	Hard dry clay, with white specs: at 60 feet 12 inches of Septarian stone occurs. The cores where tried, effervesce freely.	
150—165.	Clay becomes black and more plastic; core at 158 feet no effervescence, no white specs.	
165—175.	Water rises to surface, clay hardens	usually white specs; generally effervesces freely.
175—195.	Clay softer and paler	
195—231.	Clay darker, then lighter; 12in. stone	
At 232.	Band of red sandy matter, a few inches.	
233—321.	Clays sometimes plastic, generally pale and crumbly, with white specs, strong effervescence.	

* During the discussion on the Paper, Mr. Blake alluded to a third mode of endeavouring to explain the relations of the Vale of Pickering to the encircling Corallian rocks, viz., that these dislocations had partly occurred before the deposition of the Kimmeridge Clay, which was thus laid down in a sort of trough against a cliff line of rocks already formed. This view also has formerly found favour with Sir Charles Strickland.

† For these particulars, and for much information on the stratigraphy of the neighbourhood. I am greatly indebted to Mr. Henry Hurtley, of Malton, a member of the Association.

FEET.	
322—377.	Pale-coloured crumbly shales, sometimes nearly half soluble in acid—hard and "jetty" at 348 feet—thin bands of stone—at 353 feet "hard clay, with large white patches size of a pigeon's egg, and like salt, but tasteless" (? gypsum).
378—430.	Mostly as above, but rather less friable; at 430 feet heavy blue shale, with streaks of decomposed shell.
At 447.	"Black clay with small pebble" } clays with less effervescence.
At 460.	"Clear spar and pyrites"
At 468.	"Another hard stone: rods broke"

From a superficial inspection of these cores, it is evident that marly shales and clays constitute the formation of this part of the Vale of Pickering for a depth of 450 feet. Not a recognisable fossil was obtained. Specs and flakes of rotten shell fragments occur in many of the cores, though less so about 300 feet, where the calcareous matter seems to have been broken up finer. These presumed shell fragments lie at all angles to the axis of the bore, but mostly horizontally. No trace of bedding can be made out in the clays. Below 400 feet there is greater density, and rather less lime than immediately above. A sort of lustre may be noticed at the broken edges of some of the cores, which answers, I presume, to the "jetty" of the Report. On the whole, if we except the varying colour and plasticity of the clayey matter, there is considerable uniformity throughout; the most important exceptions are at 158 feet, where there is hardly any lime in the clay; and at 230 feet, where the red sandy bed occurs. About eight or nine bands of stony substance, showing an aggregate of some 5 feet of stone, were encountered, and these seem to have been of the nature of concretionary matter, such as occurs in clay. No sand other than the thin streak at 232 feet was found, and the clays are remarkably free from grit.

All the above facts are very much against the theory of this part of the Vale of Pickering consisting of Oxford Clay, which in this district (Hutton Banks, three miles west of Malton, is the nearest good section) is only 70 feet thick and rather sandy. But if we now turn to the Blue Clay on the opposite side of the Coralline peninsula, still more conclusive evidence is obtained. There are at least three points on this side where borings have been executed within a few hundred feet of the oolite rock; the one at *f* (Fig. 23) is the middle of these. A depth of 400 feet was attained in one case, still ending in this everlasting Blue Clay. Nothing shows the excessive steepness of the hade of the fault *B* so clearly as these futile attempts to touch the rock. This is the middle fault which cuts off the Coralline Oolite, and so forms the well-known escarpment at the south-west corner of the Roman camp above Castlegate. The rock has been worn back a little, and the actual fault runs between Castlegate and the river, being 40 feet from the centre of the street at Russell's brewery. A very short distance further down the river itself flows

along the line of fault at the new bridge, opposite the station (see Contour Map, Fig. 17). The north pier of this bridge rests in valley deposit and oolite rubble, whilst the south pier stands in "clay with ammonites and oysters." Mr. Hurtley, Mr. Mortimer, and others all concur in saying that the clay exposed was very like Kimmeridge Clay, and that the fossils were such as characterise that formation. But if any doubt should remain, an inspection of the New Cut, about one mile W.S.W. of the station will remove it. Here is an exposure, fortunately free from Superficial Beds, showing stratified blue clay with septaria of the regular Kimmeridge kind, where, in the summer of 1877, Mr. J. R. Mortimer and myself found *Ostrea deltoidea* and *Belemnites nitidus*.

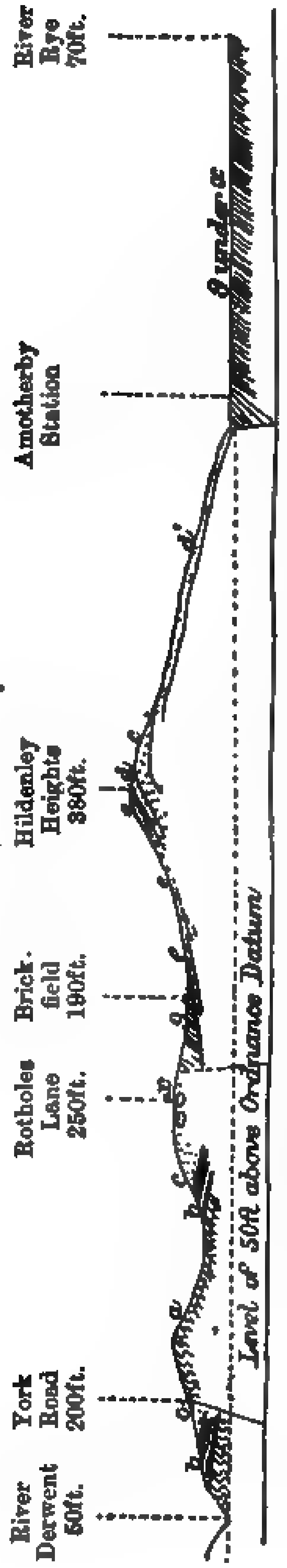
Such being an outline of the leading stratigraphical features in the immediate vicinity of the capital of the Howardians, the disappearance of the Corallian rocks would seem to be best accounted for on the supposition of a great undulating synclinal which has largely determined the physiography of this region. This system of flexures is partly preserved in the present contours of the hills, the actual *fractures* being more frequent in the Howardians than in the Tabular Range. Fig. 25 (p. 456) is a measured section (in part shown by the line, *y*, on the Contour-Map, Fig 17) across a portion of the former range of hills parallel to, and three miles to the westward of the measured section, Fig. 23.

It is not at all claimed that this section is an absolutely correct reading of the difficult bit of country between the Derwent and the Rye, but it is sufficiently accurate to show the system of flexures and fractures. The fault which forms the northern termination of the Howardians for many miles (in this section shown a little south of Amotherby Station) is undoubtedly the Malton North-fault, which is one of the master faults of the whole country. The very puzzling relations of the Kimmeridge Clay of the Hildenley Brickfield to the Middle Oolites on the south are masked by a mass of Boulder Clay; it is difficult, therefore, to say what connection this rapid change of beds has with the Middle or Norton fault. Further south there is a fault of moderate throw (York Road) which also must have some connection with the Middle or with the South fault.

Putting aside such questions as these, which can only be decided by a systematic survey, we may gather quite sufficient from a study of the above section as to the up and down character, both geologically and topographically, of this part of the Howardians, although the actual throw of the faults is perhaps less here than at Malton.

FIG. 25.—SECTION THROUGH HILDENLEY.

Distance, 5 miles 110 yards.



a. Lower Oolites. *b*. Oxford Clay. *c*. Lower Calcareous Grit. *d'*. Oolites of Swinton, &c., occupying most of the northern slopes in beds that seem subject to numerous small dislocations and changes of dip. *d*. Oolite underlying the Hildenley Stone. *e*. *e*. Coral Rag (Hildenley Stone). *f*. Cement-stone or Throstler (Supracoralline). *g*. Kimmeridge Clay. *s*. Superficial Clays, Sands and Gravels—a true Boulder Clay at Rotholes Lane.

Vertical scale 800ft., horizontal 4440ft. to 1 inch.

Having now got some insight into the structure of the encircling ranges, and having obtained clear evidence as to the relations of both of them to the great mass of Black Clay filling up the Vale, we are entitled to ask—

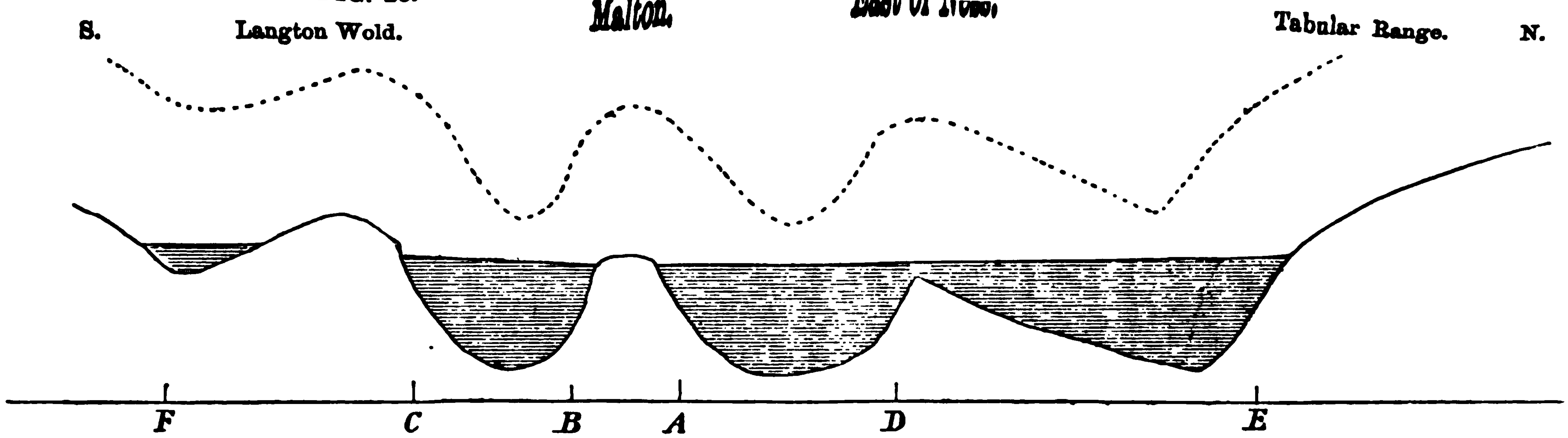
Are the Coralline rocks continuous beneath the Vale of Pickering as they should be if the ideal diagram, Fig. 26, is an approximate representation of the facts?

Or does this faulted synclinal correspond with an original lagoon-like gulf, destitute of Coral-bearing rocks?

Or, thirdly, was the depression commenced during the Kimmeridge period, and thus filled to a greater extent than the surrounding area with argillaceous sediment?

None of these questions can be answered with certainty until the boring rod has actually passed through the Kimmeridge Clay of the vale and shown us on what it really rests.

FIG. 26.—



A. Position of the Malton North fault. *B*. Position of the Middle or Norton fault. *C*. Position of the Whitewall, or South fault.

D. Probably easterly continuation of the fault on the north side of the Gap leading up to Oswaldkirk. N.B.—The clays of this remarkable gap (through which the railway from Malton to Thirsk finds a passage between the Howardian and Hambleton Hills) have always been regarded as Oxford Clay till very recently. Mr. Fox Strangways has shown, however, that this gap is a "let in" of Kimmeridge Clay which completely severs the two ranges, and the effects of which may be traced far beyond Coxwold. It is thus analogous to the "let in" of Kimmeridge Clay at Malton between *B* and *C*, the westerly termination of which, beyond Hildenley, has not yet been made out.

E. Position of the fault, or faults, at the base of the Tabular Range.

F. Position of the fault between Birdsall and Langton. N.B.—It may be doubted whether the Clay here shown is true Kimmeridge Clay or only an expansion of the Cement-stone (Supracoralline.)

It must be distinctly understood that Fig. 26 is only a very generalized section, which may be taken as approximately true of a line passing by Langton, Malton, and Pickering. In this section the faults or fractures are represented as folds, and the difference between the vertical and horizontal scale produces an amount of distortion, which the reader must bear in mind. There can be little doubt that at Malton, hundreds of feet below the surface, the Kimmeridge Clay must be faulted against the Lias. There is, therefore, a certain distance from the edge of the rock, whence a bore-hole, after passing through 400 or 500 feet of Kimmeridge Clay might cross the fault into the Lias unobserved if there were no fossils, and thus miss the Corallian Rocks altogether.

In the foregoing maps and sections no notice has been taken of minor or cross faults running N. and S. The principal lines of disturbance have an E. and W. or perhaps W.N.W. direction, and may belong to the Post-jurassic system of disturbance, which Hull (Quar. Journ. Geol. Soc., Vol. xxiv., p. 332) has noted in the Carboniferous rocks of Lancashire and Yorkshire, though he states the direction of this system to run N.N.W. in that region.

VI.—Palæontology.

The arrangement adopted in the accompanying Table may be explained as follows. Column A indicates whether or no the species has been found on a *lower* horizon in Yorkshire.

Column I.—Lower Calcareous Grit and Passage-beds include most of the fossils of the Lower Calcareous Grit proper; of the Lower Passage-beds, *i.e.*, at Filey, Scarborough, Wydale, Appleton, &c., as well as the Lower Coral Rag of Hackness; also those of the mass of the Lower Limestones generally as far as their contents are known. The great change, however, from the fauna associated with the Lower Calcareous Grit to that which is characteristic of the Coralline Oolite may be said to occur somewhere within the mass of the Lower Limestones, as the top shell-bed of that group, wherever it has been discovered, contains an assemblage whose general facies though possessed of certain characters of its own has more affinity with the Coralline Oolite than with the lower beds. The change resulting from those causes which produced this remarkable mass of oolitic limestone could not fail to make itself felt upon the life within the area and for some distance around. The effects thus brought

about seem to have been of so permanent a character, that, although arenaceous deposits (Middle Calc Grit) again prevailed for a time in some quarters, the old Brachiopodous life of the Lower Calcareous Grit, with many of its associated forms, never seems to have regained its sway in these regions.

Column II.—Coralline Oolite includes all the fossils known to occur between the top shell-bed of the Lower Limestones in the Tabular Hills (including that bed), and the base of the Coral Rag., *i.e.*, to say, the Coralline Oolite of Seamer, Brompton, &c., the Bellheads Oolite at Hackness, the Upper Passage-beds (containing the *Trigonia*-beds), the *Chemnitzia*-limestones, and indeed everything in the Pickering section beneath the equivalent of the Coral Rag (see Section, p. 423): also the whole of the limestones west of Pickering, between the Middle Calc Grit and the Coral Rag. In the Howardian Hills it embraces the majority of the oolites underlying the Rag, and especially the oolites in the immediate neighbourhood of Malton, which have yielded so many fossils from time to time. It is a very comprehensive division, and certainly includes several sub-faunas, due probably to local rather than important physical differences. The oolites between New and Old Malton have more affinities with the Rag than have those of Swinton, &c. Taken as a whole, the fauna of the Coralline Oolite of Yorkshire is a sort of mixture of Oxfordian and Corallian forms. *The almost total absence of Brachiopoda is most remarkable.*

Column III.—The Coral Rag. This, of course, is the backbone of the Corallian system. Whilst in the underlying oolites we see a *débris* derived in no small degree from pre-existing coral growth; here we see the Coral banks themselves, and what is still better for the collector, great accumulations of intercoralline brash where the shells are preserved. The extent and subdivisions of the Coral Rag have already been indicated.

Column IV.—The Supracoralline Beds include all the Fossils found in the "Throstler," "Cement stone," and Upper Calcareous Grit at Pickering, Helmsley, North Grimston and elsewhere between the top of the Coral Rag and the base of the Kimmeridge Clay.

Column B indicates whether or no the species has been found on a *higher* horizon in Yorkshire.

Columns A and B are, unfortunately, of but little use in our present state of knowledge. As regards species occurring on lower

horizons the practical continuity of the lower part of the Lower Calcareous Grit with the upper part of the Oxford Clay tends to blend the faunas somewhat. There are also several forms, if not actually identical, at least similar to those in some of the limestones of the Lower Oolites. On the other hand, the tremendous break which seems to exist between the highest Corallian beds and the Kimmeridge Clay may be partly due to our very limited acquaintance with the basal beds of the Kimmeridge Clay in Yorkshire.

It must be admitted that a Table is but an inadequate method of conveying a really comprehensive view of the life of a period in a given district. There is something so alarming in the phalanx of hard names drawn up, as it were, in battle array that readers may well be excused if they are somewhat repelled by the sight of it. And when one further reflects that in making choice of each of these names the palæontologist is afflicted by a synonymy which is yearly growing more oppressive, it is not to be wondered at if some people are inclined to despair of ever bringing order out of this terrible chaos. Perhaps when we have seen the "Stratigraphical Catalogue of British Fossils" so long promised by Mr. Etheridge, "We may for the first time expect that the complex subject of synonymy—at present the curse and opprobrium of Palæontology—will be brought within a manageable compass."* But there are other matters to be taken into consideration before we can hope to arrive at the Golden Age. It cannot be doubted that fossils have different names in different countries; one can hardly look through an illustrated work on Palæontology without being convinced of the fact that we see many an old friend under a new title. This arises from two principal causes. *Firstly*, the imperfect figure, and inadequate description (sometimes wanting entirely) of the older and frequently foreign author; and *secondly*, the existence in a fossil of some trifling difference of form, which difference is in itself well worthy of conscientious record, but affords no valid excuse for putting a totally different ticket upon its possessor. So long as the bulk of naturalists really believed in the immutability of species there was something dangerously fascinating in the prospect of finding out and describing a *form-group*, which was destined to endure no change, which might indeed be destroyed or die

* Inaugural Address before the Edinburgh Geological Society by Prof. H. Alleyne Nicholson, Nov., 1877.

out, but could never be altered. The maker of a new species would thus come to look upon his offspring with almost parental solicitude, and having stood godfather to his own child, would attach to the name given by him a peculiar interest.

In what way, then, it may well be asked, are the leading features of a geological formation to be brought synoptically before those who are desirous of becoming acquainted with its contents? Certainly a table is a comprehensive method of doing this; but in the present case I would not have any one attach too much importance to the specific names of which that table must necessarily in a great measure be composed. Setting aside cases of mistaken identification, of which there may be some in so long a list, the following points should be kept in view by way of caution.

1. The absence of a fossil from any of the columns I, II, III, IV, merely implies that it has never been found, to my knowledge, in the corresponding group of beds.

2. A more extended and systematic search would considerably increase the list, especially as regards the smaller and less obvious forms.

3. The specific names adopted only give an inadequate representation of the numerous forms or varieties which are met with.

4. On the other hand some specific names are given to forms which are clearly the representatives, one might almost say the descendants of species occurring in lower beds, *e.g.*, *Pecten Midas* in the Upper Calcareous Grit, replacing *P. fibrosus*.

We must now take a rapid survey of the principal genera which the Table contains. The Reptiles, Fishes and Crustacea are not sufficiently important or novel to call for any special remark; it is the Mollusca therefore with which principally we have to deal.

The Cephalopoda are moderately plentiful. One type of belemnite runs through the entire formation, coming into the Lower Calcareous Grit as the short thick *B. abbreviatus*, Mill., passing through the Coralline Oolite in a modified but distinctly recognisable form, and finally emerging in the higher beds as the exceptional variety so common in the cement-stone at North Grimston (in the Table referred to *B. abbreviatus*, var. *c*). In the Upper Calcareous Grit, and again in the Kimmeridge Clay, we seem to recognise in *B. nitidus* the attenuated representative of this latter. Of course it may be pure imagination on the part of a palæontologist to attempt to establish a connection between

any of these forms. On the other hand some might take the bolder view that they were all varieties of one great group to which one specific name should be applied. But whether, as regards nomenclature, we adopt the connective or disconnective method, the fact remains the same as above stated. This serves to illustrate what the careful watching of fossil forms on gradually ascending horizons must often have impressed upon the observer, viz., the modifications introduced by time in some, though not perhaps in all, cases. When we meet a friend, after an interval of many years, the changes in his visage are manifest, but if we see him every day, although conscious of that change, it is less striking.* So it is with a fossil. If we can trace the successive changes in a series of forms through a group of beds which do not present us with a total change of conditions, we seem to see the missing links, and get accustomed to the alteration. An admirable instance of this has lately been adduced by Mr. Meyer with reference to the Micrasters of the Chalk.† But if on the other hand an important physical change, bringing about a stratigraphical hiatus, and in some cases even an unconformity, has occurred in our area, when the old state of things is restored, we immediately describe the modified form which occupies the analogous position as a totally distinct species. For purposes of constructing a table this simplifies matters very much, whilst it is the perpetual recurrence of these missing links which constitutes one of our difficulties.

Another type of Belemnite tolerably plentiful in the lower beds is *B. hastatus*, Blainv., a specimen not to be easily separated from this

* As the actual question is one of races and not of individuals, this comparison is only just up to a certain point, viz., as illustrating how we may become familiarised with changes of form, and how on the other hand such changes may produce a far stronger impression. Neither must it be inferred from previous or subsequent remarks that palæontologists are not justified in recording these differences of form by *some* change of title. If, however, palæontology aspires to the rank of a science, it will be necessary to systematise these efforts at discrimination. Otherwise each country will have totally distinct names for fossils either identical or closely allied, thus producing different languages as it were—rebuilding, in fact, the Tower of Babel with all its concomitant confusion.

† "Geol. Mag." for 1878 (March), p. 115, where the author shows that there is a sort of regular gradation in the variation between the relative positions of the mouth and apical disc of *Micraster cor-anguinum*, and that such systematic changes are coincident with slight differences of Geological horizon. When it is possible to calculate the vertical position of a given bed of chalk by means of the angle thus obtained, Palæontology may take rank with the exact sciences!

occurs as high as the Cement-stone. A third type includes certain long narrow forms of considerable size, which in appearance are not unlike *B. Owenii*, Pratt, though it is by no means sure that this identification is correct.

As regards the ammonites of the lower beds, I must refer to a previous paper.* The Coral Rag is not remarkable for the abundance of its ammonites: such as occur in the soft beds associated with that formation cannot be quoted as carrying out the view of descent with modification, since the state of preservation is usually too indifferent for the establishment of niceties of form and ornamentation. The *varicostatus* var. of *A. plicatilis* seems to be the most common form, but when the inner whorls only are found it is difficult to make out much difference. There occurs, however, a very interesting modification of *A. vertebralis* at Sike Gate on Cawton Heights, leading on from the older form to the newer *A. alternans*. See figure and description of *A. Cawtonensis*, Bl. & H. in the "Corallian Rocks of England."† Whilst, then, the Cordatus group may be said to occur throughout, though in forms which seem partly to replace each other, it is very curious to note how *A. perarmatus* of the lower beds is superseded by the *A. plicatilis*-group in the Coralline Oolite and Rag. These two forms seem hardly ever to meet, as though they were mutually repulsive to each other. In the Passage-beds of the Scarborough district a compromise seems to have been effected, resulting in *A. Williamsoni*. This splendid ammonite has not yet, to my knowledge, been found in Yorkshire out of the Scarborough district, nor do I know how far it ranges downwards into the Lower Calcareous Grit proper.

In the Cement-stone of North Grimston there are many ammonites, but usually their state of preservation is far from satisfactory. Well-marked biplicated forms are seen in the fragments of stone obtained from the quarrymen, and there are other fragments showing very large ribs, this evidence leading to the inference that a kind of *A. varicostatus* still prevailed: specimens of *A. alternans* are also obtained. The Upper Calcareous Grit at Pickering has yielded many fragmentary forms. These may be referred to *A. varicostatus* or to *A. Achilles* (much the same thing perhaps) and to *A. decipiens*? whilst some rather

* "Yorkshire Oolites," Part ii, sect. 1. Proc. Geol. Assoc., Vol. iv, p. 390.
† Quar. Journ. Geol. Soc., Vol. xxxiii, p. 392, pl. xiii, fig. 2.

fine specimens from the railway cutting at Kirkdale are quite Kimmeridgian in their character. All these forms, with the exception of *A. alternans*, seem modifications of the old plicatiloid type (See also *ante*, p. 447).

Both Coralline Oolite and Coral Rag contain the remains of numerous Gasteropoda, and in this respect present a strong contrast to the formations immediately above and below. The Lower Coral Rag and Lower Passage-beds, so rich in many of the Mollusca, are almost destitute of Univalves, whilst nothing beyond squeezed specimens of *Chemnitzia* and one doubtful *Patella* have as yet been found in any of the Supracoralline beds. It has long been a subject of reproach to the Corallian formation of this country that it is not rich in species, and the late Professor Phillips had even a worse opinion of it, when he described it as being a "pauperized" fauna.* Although the Professor spoke more especially of the neighbourhood of Oxford, he must also have had the Yorkshire deposits in his mind. As regards mere number of species there may be some truth in this, but certainly not as regards individuals. So far from the Corallian of Yorkshire showing a "pauperized" fauna, it exhibits the flowering of Jurassic life within the area as regards the Gasteropoda, as regards many of the Conchifera, and as regards the Echinodermata. This rule holds good both as to the number of individuals and as to the size attained. But considering the extent of the formation in Yorkshire and the numerous shell-beds it contains, the list of species seems only moderate. This arises partly from the excessive difficulty of extracting the shells from the matrix, and the still greater difficulty of developing them so as to show specific characters.

There are enormous masses of *Chemnitzia* in various parts of the Coralline Oolite, so hopelessly sealed up that tons of them are fractured by the quarrymen. Every one of these, so far as is known at present, are referred to *Ch. heddingtonensis*, which sometimes attains a length of 8 or 10 inches. This shell, when well preserved, as in the "small shell-bed" at Pickering, has a very strong resemblance to *Ch. vittata* of the Cornbrash, and has indeed a very long pedigree, for it is distinctly identified by Deslongchamps as occurring in the Inferior Oolite of Normandy. This

* "It is perhaps safe to view it as a 'pauperized' fauna, indicating the approaching extinction of physical conditions which marked the Oolitic ages and influenced the life of the period.' Phillips "On the Geology of Oxford," p. 394.

means nothing more than that the great genus *Chemnitzia*,* which culminated in the Jurassic period, then included a form limited in numbers, but ultimately preponderating in Corallian times above all others of the genus. This shell, along with certain species of *Nerinæa* and others less plentifully distributed, is the principal constituent of shell-beds which may be traced for great distances, especially in the Tabular Hills and also in the Malton Oolite. Reference will be made to this when we come to consider *Nerinæa*. In the Coral Rag, which is the principal museum for the rarer univalves, besides doubtful varieties, three very well-marked species have been found, though at present their identification rests upon very few specimens. One of these, *Ch. langtonensis*, figured and described in the "Corallian Rocks of England,"† is at present unknown elsewhere, and is altogether so remarkable a shell that its relationships are not quite clear.

There is a small univalve bed in the Coralline Oolite of Pickering, and a somewhat similar bed has been found in a quarry near Ness (Cawklass), which is full of *Cerithia*, and probably of *Nerinææ*, yet the number of determined species is very small, and one is apt to look with envy upon the wonderful list of this genus, which has been put together by Buvignier, from the Corallian of the Department of the Meuse. Again, the terrible difficulty of extracting from the rock impedes us. *C. muricatum* (out of which perhaps one or two varieties might be carved), is plentiful in some of the shell-beds of the Coralline Oolite ; but its place seems to be taken by *C. limæforme* in the Coral Rag. At least, I don't remember ever to have found *C. muricatum* in any of the Rags. In the Howardian Coral Rag, especially in the Langton Wold and Grimston quarries, this genus does not seem well represented.

Nerinææ, next to *Chemnitziæ*, are the most abundant of all the Univalves. Individually they are, perhaps, more numerous in the Coralline Oolite, but the Coral Rag contains possibly a greater number of species. There is a variety of this peculiar and extinct genus, which at once arrests our attention. Biologically it forms a connecting link between the Nerinæas and the Actæons, and seems peculiar to the Corallian formation. Several "species" are recorded by d'Orbigny from the Corallian of France, and amongst

* De Loriol separates these from *Chemnitzia* and unites them with the "*Phasianella*" of the Oolites to form a genus *Pseudomelania*.

† Quar. Journ. Geol. Soc., Vol. xxxiii, p. 393, pl. xiii, fig. 3.

others *N. fusiformis*, which is excessively plentiful in the inter-coralline chalky mud of the Rag at Brompton. A larger form, almost answering to his *N. clymene*, is also met with on the same horizon in the Rag pit at Ruston.

The elongated, or more typical forms of *Nerinæa*, are met with sparingly in the oolite of the Lower Limestones, but never in a condition where it would be safe to attempt a specific name. Throughout the Coralline Oolite, especially at Pickering, the various shelly horizons, even as low down as the *Trigonia*-beds abound with *Nerinæa*, usually referred to *visurgis*, Rœm.; but there is more than one form, and it may be doubted if the real *visurgis* be amongst them. Out of the unapproachable figures of *Nerinæa*, which d'Orbigny's skilful artist has presented to us, there are some to which our rolled and battered Yorkshire specimens bear a faint resemblance. In the Rag again, where this group of univalves is not quite so plentiful, there is an immensely long, narrow species, well described by Bean's term *allongiuscula*, whatever may be its more correct identification. The most common species throughout is *N. Rœmeri*, and there may be others besides the three to which the majority of the specimens are referred.

If we were disposed to describe a portion of the Coralline Oolite as a *Nerinæa* or *Chemnitzia* Limestone, it would be quite in accordance with the facts, and yet in Yorkshire this subformation lies *below* the zone of *Cidaris florigemma*, or Coral Rag; whereas, in Eastern France, the so-called Nerinæan zone is within the Epi-corallien of Thurmann, and therefore *above* the great bulk of madreporic limestone of that region. Hence the inapplicability of such terms as Nerinæan* zone is most obvious, except for purposes of local description; hence, also, the impossibility of a too rigid correlation being attempted between areas widely separated.

The smaller univalves are principally confined to the Coral Rag, which contains species of *Littorina*, *Nerita*, *Neritopsis*, *Turbo*, *Trochus* and *Delphinula*. With the exception of *L. muricata*, and its very near relative, the *L. pulcherrima* as identified, none of these are very plentiful. We have a poor list to exhibit in comparison with that of Buvignier from the Coral Rag of the Meuse,

* Since De Loriol has proposed that the term Étage Corallien should be altogether suppressed, as only leading to confusion, *a fortiori*, therefore, such terms as Nerinæan-zone.

and it also compares disadvantageously with the Inferior Oolite of Bradford Abbas, and the Great Oolite of Minchinhampton. The fact is that, in this formation, a small shell has a poor chance of being detected unless it is developed by weathering, and too often the process has gone too far. Still the shells are there, and it may well be doubted if this apparent poverty is the result of such a very restricted fauna as Prof. Phillips supposed. The chalky Coral Rag of Upware contains numerous casts of small univalves, and there is considerable analogy between its fauna and that of the Coral Rag of the Howardian Hills, east of the Derwent; hence we may hope to find more in course of time.

The genus *Pleurotomaria* was evidently on the decline; besides the species, or varieties quoted, there is a very fine *Pleurotomaria* in the Rag of North Grimston, but I have not been able to extract it and therefore it is unnoticed in the Table. The remainder of the Gasteropoda in the list call for no special remark. It may, however, be noted that *Cylindrites elongata*, Phil., so characteristic of parts of the Lower Limestones, has been most inadequately figured by that author; his representation (Pl. iv., fig. 7), merely shows the interior of the whorl. The shell most probably appears in some other work, and of course under another name.

The Anatinidæ and Myacidæ are not particularly numerous in the Coralline Oolite or Coral Rag generally; not nearly so abundant, for instance, as they are in the Cornbrash and other members of the Lower Oolites. In most parts of the Rag and in the *Trigonia*-beds of Pickering, these two families are poorly represented, but some of the oolites about Malton contain several fossils belonging to them. Their state of preservation is usually so indifferent that determinations are not very satisfactory. Such being the case, the differences between the common forms of *Goniomya*, for instance, and those which occur in the Kelloway Rock do not seem to be very great. This subgenus is extremely plentiful in the Upper Calcareous Grit of Pickering, and the Cement-stone of North Grimston, where specimens attain an unusual size, becoming complete megalomorphs in fact, but yet not differing very much from the regulation *G. litterata*, or *G. v-scripta* of our English palæontologists. It would not be difficult, perhaps, to increase the number of species of *Myacites* recorded in the Table, if one were disposed to match every variety of form with the figures in Agassiz' work. Some of these forms, such as that referred to *M. jurassi*,

Brogn., appear to run through nearly all the Oolites, though with such a number of aliases, that their identity seems lost. The *Pholadomyæ* present more salient features for specific identification, and, as usual, there is an infinite choice of names. The forms identified with *P. decemcostata*, Rœm., and *P. æqualis*, Sow., will include most of the more or less elongated varieties, whilst the large deltoid *Pholadomyæ* are placed under the head of *P. parcicosta*, Ag.* These shells are ventricose, truncated in front, and ornamented with salient ribs, few in number, sometimes no more than one. The Malton collectors obtain them, but I have never been able to ascertain the precise horizon on which they occur. This may be the same shell as the *P. paucicosta* of Rœmer, and the *P. ventricosa* of Goldfuss, the former being said to occur in the "Upper Coral Rag" of Hildesheim.

The genus *Astarte* is very well represented, both as to individuals and species. The forms in the lower beds are *A. Duboisiana*, and *A. extensa*, and more rarely the great species found at Wydale. *A. Duboisiana* is extremely characteristic of the Coralline Oolite of Seamer, Ayton, &c., and occurs as a megalomorph in the equivalent Bellheads oolite at Hackness. It is also very common in the base of the Coralline Oolite of Pickering along with *Nerinææ* and some corals. The most frequent *Astarte* of the higher part of the Coralline Oolite is *A. ovata*, and this attains a large size, being frequently found with both valves in the Coral Rag of North Grimston. This species is particularly plentiful in the shell-beds of the *Chemnitzia*-limestones and oolites. It usually occurs in the oolites with a perfectly smooth exterior, the whole of the surface markings having been removed by attrition, or by that peculiar process of "sweating," which is so destructive of many of the shells. But if preserved under favourable conditions, as, for instance, in the great shell-bed of the North Grimston Rag, where the fossils have not been rolled, and where the slightest trace of marking on the surface has been most faithfully copied in the calcitic replacement of the original shell, the delicate concentric lines of growth which form its only ornament, are very distinct. This is a very common form throughout the Oolitic System; but little real differ-

* "C'est une des espèces les plus communes du Jura Suisse; elle est surtout caractéristique pour les strates de calcaire vaseux, alternant avec les marnes subsableuses du groupe Oxfordien des régions littorales."—Agassiz, Moll. Foss., p. 99.

nce seems to exist between our shell and *Astarte modiolaris* ? = *obliqua*) of the Inferior Oolite. We can also trace the form n some of the plates of foreign palæontologists, though of course ınder a different name. As an extremely common species it would aturally throw off a certain number of varieties, and some of hese might "take," or be perpetuated, but yet the type form eems to have been recurrent, with very slight modifications indeed, t periods sufficiently remote. A case like this affords an illusration of the extreme difficulty of giving an adequate idea of the ossil conchology of a formation through the agency of "specific" omenclature as at present adopted; hence the necessity, as I reviously pointed out, of taking our Tables *cum grano salis*. In his particular instance, one cannot help wondering whence came his *Astarte ovata* into the Coralline Oolite, since we fail to find it n the shell-beds at the base of the Lower Limestone. On the ther hand what was the fate of the descendants of *Astarte pro-lucta*, that very common little shell of the Lower Passage-beds ?

Astarte rhomboidalis, which externally is very like a *Hippopo-lium*, first enters an appearance as a micromorph in the Lower Coral Rag of Hackness, and has never, to my knowledge, been found n the Coralline Oolite, but is plentiful in the Howardian Rag. This shell seems identical with the one occurring in the Inferior Oolite of Bradford Albas and the Great Oolite of Minchin-ıampton.

The genus *Opis* is one of such marked outline, and such pro-ıounced ornamentation, that its various forms are more easily caught ınd differentiated. Hitherto, in the Yorkshire list, *Opis Phillipsi* ıas usually included *O. corallina*, and all the small varieties, but hese are subject to great differences throughout the entire series. The Coral Rag of Langton-Grimston has yielded us a few speci-nens of two far larger species, viz., *Opis virdunensis*, and *O. lunu-ata*.* The seeming connection between the fauna of this Rag of he Eastern Howardians and the small but very rich exposure at Upware is curious. In Yorkshire we get the shells, in Cambridge-hire the casts, but the former are rare, the latter plentiful.

The Lucinidæ are amongst the more numerous bivalves of the Coralline Oolite, and they constitute the bulk of the shells as yet

* These occur, the former abundantly, in the Coral Rag of Upware, along rith *Opis paradoxa*, and *O. arduennensis*, d'Orb., in addition to the *Phillipsi-corallina* group.

recognised in the Supracoralline beds. The physical conditions of the Coral Rag seem to have been less favourable for them. The genus *Lucina* itself, is most fully represented by unornamented forms of moderate dimensions, such as those referred to *L. aliena*, and *L. globosa*, which, along with *Ch. heddingtonensis* and *Nerinæa*, make up the bulk of the shell-beds in the *Chemnitzia*-limestones and oolites (Coralline Oolite); these two are closely allied, and perhaps pass into each other. The less common forms require to be well preserved in order to admit of identification. As regards those species which are so common in the Upper Calcareous Grit, it has been thought advisable to adopt the named form which most resembles them, but the identifications must be received with caution. I have not yet succeeded in finding the foreign synonym for the large and handsome *Lucina ampliata*, if the shell really is a *Lucina*. "Malton" alone yields it, but whether it comes from the Upper Oolites of Malton, &c., or the presumed Lower Oolites of Swinton, &c., is unknown to me; and the same remark is applicable to the fine series of *Corbis* or *Corbicella*,* which serves to connect our Yorkshire Corallian with those districts, whence Buvignier's fine shells were obtained. *Tancredia* and *Unicardium* are found sparingly, though these and many other shells, such as *Myacites*, &c., were possibly the originals of the half-dissolved casts so often met with in the upper part of the Swinton Oolites.

The *Trigoniæ* have been so exhaustively treated in Dr. Lycett's admirable monograph, that it is not necessary to say much in explanation of this portion of the Table. The specimen from the Upper Calcareous Grit referred to *T. Voltzii* might perhaps be open to doubt. When one looks over a large series of clavellate forms from the *Trigonia*-beds (Upper Passage-beds) of Pickering, it would not be difficult to pick one out that would match it. The discovery of a well-marked and very handsome species, belonging to the group *Scaphoideæ*, in the Lower Passage-beds, is one of considerable interest. This species, called by Dr. Lycett *T. snaintonensis*, follows the type of *T. recticosta*, so characteristic of the *Millepore*-bed of the Inferior Oolite, but there are very obvious differences of ornamentation, and as the missing links which must have existed somewhere during the long time which elapsed between the two formations, are not forthcoming at present within the Yorkshire

* Mr. Blake obtained a specimen from one of the quarries at Malton.

area, the claim of this form to specific distinction is a very good one.

It is difficult to avoid remarking that the coarse gritty limestones and marly sands of the "Yorkshire Oolites" generally, have been prolific of small and curiously-marked *Trigoniæ* belonging to the so-called Scaphoideæ and Undulatæ; and it may be a question for subsequent investigation how far these local and vertically limited forms are due to mere variations in larger, and more widely distributed species superinduced by the coming on of "estuarine" conditions; or, on the other hand, whether each sandy "estuary" was not provided with varieties of race especial to itself—*T. snaintonensis*, however, has a considerable horizontal range, as Dr. Barrois has sent it to me from the Upper Oxfordian of the Ardennes, where it is associated with a fauna not on the whole dissimilar from that of the Passage-beds.

The *Arcadæ* are both numerous and conspicuous, especially in the upper beds; *Arca* and *Cucullæa* seem to have affected the neighbourhood of Coral Reefs. The two commonest forms in the Rag are *A. pectinata* and *A. quadrisulcata*, but along with these occurs a large *Arca* or *Cucullæa*, also found in the Malton oolite, which seems to replace *C. corallina*, the species so plentiful in the *Trigonia*-beds at Pickering, and elsewhere in England. Some of the smaller species of *Arca*, especially from the lower beds, may turn out to be micromorphs of forms attaining greater dimensions in the Rag.

Of the aviculoid Monomyaria, *Gervillia* is by far the most abundant, so much so that the shell-beds of the Lower Limestones generally may be called *Gervillia*-beds, just as those of the Coralline Oolite are called *Chemnitzia*-beds. The genus *Avicula* is very well represented both in species and individuals in the lowest beds, but is rare in the Coralline Oolite, and almost unknown in the Coral Rag. The most characteristic species, and one peculiarly Corallian, is *A. ovalis*, which here performs the part of *Avicula echinata* in the Cornbrash. It makes its appearance probably somewhere in the Lower Calcareous Grit, and attains its maximum size, and abundance in the lower Passage-beds, especially at Appleton. This variety is also found in the Swinton Oolite, which contributes to strengthen the view that that rock is related to the Lower Limestones. Tracing it upwards through the Coralline Oolite, its form changes, whilst its size is reduced, and

finally, in the Upper Calcareous Grit, there is a form so different as almost to merit another name. Here the curtain drops, and when next we obtain a glimpse of another act in the Jurassic drama of Yorkshire *Avicula ædilignensis*, so common in the lower Kimmeridge of Hildenley and Burdale, has possession of the stage: this species, however, is allied to *A. inæquivalvis*, and not to *A. ovalis*.

The Ostræidæ are well represented. *Lima* is very abundant and varied, the shells of the different species attaining a great size, especially in the Rag. Again we seem to have some Lower Oolite forms. *L. pecteniformis*, so common in the Inferior Oolite of Cheltenham and Cornbrash of Yorkshire, is one of the leading fossils of our Coral Rag, and it would be difficult to separate the *L. gibbosa* of the Lower Passage-beds from the well-known species which first appears in the *Spinosa*-stage of the Inferior Oolite of the Cotteswolds.* Some of the other forms are similar rather than identical with those of preceding formations. The true *Lima læviuscula* (var. b.) and *L. rigida*, neither of which I have as yet found of any size in the Lower Limestones, are amongst the most characteristic fossils of the Coralline Oolite and Coral Rag in the Howardian Hills, and also at Oxford. The two splendid fossils figured in Pl. vi. are portraits of individuals rather than of species. In the Table they are referred provisionally to known species, in order to obviate the necessity of giving new names. These identifications might not perhaps suit every palæontologist. In the Ayton-Brompton Rag a smaller species with finer lines is very numerous.

The Pectens also are very numerous and attain magnificent proportions in the Malton oolite, as an inspection of the Museums at Cambridge, York, and Scarborough will prove. In this genus we see no signs of a pauperised fauna, but each form-group culminates in size and beauty, having passed on from the older Jurassic beds, where, as in the Cornbrash, the ancestors of *Pecten lens*, *P. vimineus*, *P. fibrosus*, and *P. inæquicostatus*, amongst others, are not difficult to recognise—nay, we can trace their likeness in still older beds. Yet in the lower Corallian of Yorkshire—on the horizon, for instance, of the Hackness lower Coral Rag, often so very fossiliferous, and generally, in fact, until towards the top of

* It is more like *L. gibbosa*, Sow., than it is like *L. lepida*, Dollf.

the Lower Limestone—the genus is represented by small forms, amongst which *P. vagans-fibrosus* is by far the most numerous. To what cause, then, are we to attribute this increase in the size of the individual, and the complexity of the forms? Is it that the finer species kept out of the area during those periods of adversity when the Oxford Clay and Lower Calcareous Grit were being deposited; or are these results due to the effect of favourable conditions stimulating into activity capacities otherwise dormant? Closely associated with *Pecten* is the sub-genus *Hinnites*, and in no section of the Mollusca do we seem to see greater variation according to conditions, yet with an approximate retention of original form. There is, however, in the Coral Rag throughout England a most characteristic representative of *Hinnites*, which attains an immense size at North Grimston, and is well worthy of specific designation. This is also true of the so-called *Anomia radiata*.

The Oysters proper are, of course, the most numerous of all the Mollusca. The sandy and clayey beds above and below contain the large Gryphæas, which disappear or are modified in the more calcareous parts. Some of the intercoralline portions of the Rag are a mass of oysters, especially on Langton Wold about the Grand Stand. These are generally called *Ostrea duriuscula*, which is the name of a flat valve of no very marked characters, figured by Phillips. As this Rag is high, and probably above the *florigemma*-zone in places, one might expect to find some of the figured forms of continental authors. The innumerable small oysters which occur from the base to the summit of the formation are conveniently lumped under the general heading of *Exogyra nana*. The plaited or coxcomb oysters offer more interesting forms, and in the lower beds on the coast modifications of the old *Ostrea flabelloides* are often seen, whilst the *Ost. gregaria*, also an older form, swarms in parts of the Rag.

Allusion has been made to the Brachiopoda of the lower beds in a previous paper.* Above the basement beds of the Lower Limestone they seem to be scarce, and in the Coralline Oolite are almost absent. One bad specimen of *Rhynchonella* and a still more dubious *Terebratula* are all I have ever seen. A similar scarcity was noted at Oxford by Whiteaves, and obtains through-

* Proc. Geol. Soc., Vol. iv., pp. 394 and 403.

out England. *T. insignis* (var. *Maltonensis*) occurs in the Coral Rag, being found at the Whitewall quarry on the northern face of the Langton Wold ridge.* The Echinoidea of the lower beds† have already been alluded to in the above-quoted paper. For further information I must refer to the Table of fossils, merely remarking that the rule as to increase of size in the higher beds is especially true of the Exocyclic urchins, where the same species ranges throughout. This is especially noteworthy in *Collyrites bicordatus*, *Echinobrissus scutatus*, and *Pygurus pentagonalis*. A specimen of the latter found by me during the autumn of 1877 in the Grimston Field Rag-quarry is very much larger than the biggest specimen figured by Dr. Wright.

There are not more than ten species of Corals at the utmost enumerated from the Corallian of Yorkshire, and of these *Isastræa explanata* and the two species of *Thamnastræa*, together with *Thecosmilia annularis*, make up the bulk of the reefs. The lower Jurassic beds show a greater variety in this respect, though not perhaps in Yorkshire. Many species have lately been described from the Lias of the West Midlands, where they seem to occur in isolated patches of small extent, but highly prolific in variety of form. The Coral reefs of the Inferior Oolite in the Cotteswolds, occurring on three distinct horizons, are also richer in species than the far more bulky Coral Rag. We must regard the whole Jurassic period, therefore, as one where reef building conditions prevailed when the opportunity was suitable, and this is generally admitted to afford evidence that the isocryme of 68°F. then prevailed at least as far as the latitude of North Yorkshire.

The Coral Rag and its accompanying *débris* are the remains of the *last* great effort of the reef building species in our islands, and nowhere else in Britain has the *Astræa* tribe left such a monument of its energies as in East Yorkshire. To the geologist, who is above all things the historian of the earth's progress in time, the remains of these latest reef building Corals that ever grew in the British area must present features of considerable interest. Compared with the stupendous masses in existing æquatorial seas, the accumulations which have been described in this Paper may seem scanty even in the region of their greatest development.

* Cf. Hudleston and Walker—"Oolitic Brachiopoda of Yorkshire," Proc. York. Phil. Soc.

† *Loc. cit.*, p. 394.

Doubtless they must be looked upon as shallow water deposits supported on sand banks and shell beds, rather than on submerged peaks such as those of the Indian and Pacific Oceans, whose rapid declivity and continuous descent have afforded opportunities for such enormous thicknesses of Coral rock to be built in recent times.

There is no evidence of the formation of Coral reefs in the British seas during the Cretaceous period; yet they are met with in the contemporaneous deposits of central and southern Europe. The last traces of reef building Corals had not been extinguished from southern Europe even in Miocene times, but since then all parts of Europe have become too cold for them. When we couple these facts with a study of the development of reef building Corals in times anterior to the Jurassic, we seem to obtain important evidence as to the climatal history of our planet which physicists and speculative mathematicians, ignorant of or indifferent to geological history, can alone afford to ignore.

Notes on the Fossils Figured.

Nerinæa visurgis, Auctorum, non Rœmer. Pl. iv, figs. 1*a* and 1*b*. —This species is locally abundant, especially in the Coralline Oolite of Seamer and Ayton, and at the base of the Coralline Oolite, Pickering. 1*a* is an unusually good specimen for Yorkshire, yet the shell is so worn that the ornaments are more or less obliterated, especially towards the apex. I have never seen a specimen of the real *N. visurgis*, Rœm., but if it is anything like the figure (Nordd. Ool. Geb., t. xi., fig. 28), it is much more obtuse-angled than our species. In the small shell-bed at the base of the Coralline Oolite, Pickering, are many specimens of *Nerinæa*, of which 1*b* has been selected for figuring. It probably represents a younger stage of this species.

Nerinæa Rœmeri, Phillipi, in Goldfuss. Pl. iv, figs. 2*a*, 2*b*, 2*c*. —This species is by far the most abundant and widely distributed, both vertically and horizontally, but usually so disfigured that the ornamentation is lost. The figure in Goldfuss (Petref., t. 176, fig. 5*b*) is very like the majority of those Yorkshire specimens, whose ornaments have to any extent been preserved. Ours is certainly not the *N. fasciata*, Rœm. (Nordd. Ool. Geb., t. xi., fig. 31); neither is it the *N. fasciata*, Voltz (N. Jahrb., 1836, t. vi., fig. 21), which may or may not be the same species. In *N. Rœmeri* the apical angle is more obtuse than in either of these, and the

shell is altogether shorter and stouter. 2*a* is a full-sized specimen from a very rich block of the Ayton or Seamer Coral Rag. The artist has a little overdone the restoration of the ornaments, especially at the sutures, but the figure may be taken as a fair representation of one of the best preserved specimens I have been able to procure. The others are fragments of probably the same species in different conditions of preservation, which may account for the somewhat different character of the surface.

NERINÆA, cylindrical species. Pl. iv., fig. 3.—This is probably the *N. allongiuscula* of Bean. The angle of this shell corresponds pretty nearly to that of *N. fasciata* according to Rœmer's figure, but the ornaments, as far as these can be made out, do not seem to correspond. It has been confounded with the far commoner *N. Ræmeri* under the general term *N. fasciata*. I have seen very long individuals, probably belonging to this species with every trace of ornament destroyed. The specimen figured is merely a fragment; the apical angle at once shows it to be different to either of the other species. Cf. *N. sexcostata*, d'Orb.

PSEUDOMELANIA, species. Pl. iv., fig. 4.—This has far too blunt a cone to be the well-known *Ps. heddingtonensis*; *Ps. collisa*, de Lor., is something like, yet hardly the same. Should further search disclose better specimens this form may be worthy of specific description.

TROCHUS, cf. ACUTICARINA, Buvignier; TROCHUS INORNATUS, Buvignier; TURBO LÆVIS, Buvignier; TURBO CORALLENSIS, Buvignier.—Pl. iv, Figs. 5, 7, 6, 8.—These are all specimens from the Corallian of Yorkshire, and with the exception of the last (often mistaken for a *Nerita*) have as yet been very rarely found.

QUENSTEDTIA LÆVIGATA, Phillips. Pl. iv, figs. 9, 10, 11.—The specimen figured by Phillips ("Geol. Yorks.," vol. i, Pl. iv, fig. 5) is much smaller than fig. 9, but the general character is the same, with its round anterior margin, and the produced and subquadrate character of the posterior margin. The generic characters are given in Morris and Lycett, "Bivalvia," p. 96. Distinguished from *Psammobia* by the position of the ligament which is placed in a narrow fossa, this feature is common to all the three shells figured, and may serve to distinguish them from *Panopæa*, *Arcomya*, &c., to the latter of which Fig. 11 has a strong external resemblance. The dentition is obscured more or less in all the specimens by wear, or by the adhesion of fragments of oyster shells. The group

appears moderately plentiful in the Malton Oolites. Whether the forms figured have any claim to specific distinction, or are simply varieties of over growth (megalomorphs), it is impossible to say.

Cucullæa corallina, Damon. Pl. v, fig. 12.—Damon's figure ("Geology of Weymouth, Supplement, Pl. iv, fig. 8) gives the character of this species fairly, but there is no description. Phillips' *C. oblonga* ("Geology of Yorkshire," Vol. i, Pl. iii, fig. 34) is probably intended for this species. Lycett, in the "Supplement to the Great Oolite Mollusca," figures a shell from the Cornbrash of Scarborough, which he refers to this species ("Supplement" t. xxxix, 3). The figure is certainly not characteristic of the Corallian form, though, no doubt, the two are closely related.

This species, as found in the *Trigonia*-beds at Pickering—its head-quarters in Yorkshire—is short, tumid, and abruptly truncated, but is especially characterised by the ornamentation on the anterior side. This consists of a few well-defined but distant radiating lines decussating with the densely arranged longitudinal lines which pervade the entire surface. This seems more conspicuous on the left valve than on the right one. The radiating lines on the posterior surface are only just visible and appear to have been wanting in the centre. It is probable that *C. contracta*, Phil. ("Geology of Yorkshire," Vol. i, Pl. iii, fig. 30) may be intended for a small and very truncated form of this species.

Cucullæa elongata, Phillips, non Sowerby. Not figured.—It was originally intended to give a figure of this large form, as the *C. elongata* in the " Geology of Yorkshire " (Pl. iii, Fig. 33) is a very inadequate representative of our shell, if, indeed, it be really meant for it. The *C. elongata* of Sowerby is totally different, but *C. oblonga*, Sow., from the Inferior Oolite not unlike; hence probably the mistake. Some of the foreign names—such as *Arca Laura*—would almost do. In comparison with *C. corallina* this shell is more produced in proportion to its height, and has less angularity and abrupt truncation. All the specimens seen by me are destitute of ornament, but this may be due to attrition. Mr. Reed has a fine example 3½ inches long, from the Coralline Oolite of Malton. We may regard this shell as taking the place of *C. corallina* in the upper part of the Coralline Oolite and in the Coral Rag. Doubtless, intermediate forms must occur.

Trigonia Blakei, Lycett; and Trigonia snaintonensis, Lycett. Pl. v, figs. 13 and 14.—Named by Dr. Lycett from

specimens obtained by me at Wydale. *T. snaintonensis*, which is a very well-characterised species, locally rather abundant, is described in the "British Fossil Trigoniæ," p. 198. It is believed that *T. Blakei* will shortly be described and figured by Dr. Lycett.

Avicula ovalis, Phillips. Pl. v, figs. 15*a* and 15*b*.—Figure 15*a* shows the variety characteristic of the Passage-beds just above the Lower Calcareous Grit at Appleton: Fig. 15*b*, represents the variety which occurs sparingly in the Coralline Oolite of Malton. It might almost be taken for the young of *Hinnites*.

Pecten inæquicostatus, Phillips, Pl. v, fig. 16.—The right valve (16*a*) is the form usually known under this title, and the left valve (16*b*) not seldom goes by some other name. These are opposite valves of the same individual shell fitting without the least displacement. The specimen, which belongs to Mr. Reed of York, has been kindly lent for the purpose of illustration; it is probably the finest of its kind in any collection. The ears are drawn from other specimens.

Lima subantiquata, Rœmer. Pl. v, fig. 17.—This well-marked species of *Lima* is figured from a Yorkshire specimen, not quite well enough preserved to show the true character. Its outline seems different to that of any other species of *Lima*.

Lima, species. Pl. vi, fig. 18.—This magnificent specimen, the property of the Yorkshire Philosophical Society, has been kindly lent for illustration. In the table of fossils it is provisionally referred to *L. læviuscula*, var. c.

In English works dealing with palæontology the large Corallian forms have hitherto been referred either to *L. læviuscula*, Sow., or to *L. rigida*, Sow. But shells extremely different to these well-known types are not unfrequent. In Rœmer's work (Nordd. Ool. Geb.), we find two large Corallian Limas described and figured; viz., *Lima tumida*, Rœm. (Pl. xiv., fig. 1) from the Upper Coral Rag of Hildesheim, and *Lima grandis*, Rœm. (Pl. xiii., fig. 10), from the Lower Coral Rag of Heersum.

The shell now figured has been occasionally identified with *Lima tumida*, no doubt on account of its suborbicular figure, and to a certain extent similarity of ornament. This may be near the mark. In order, however, to avoid the risk of a wrong identification, and also to obviate the necessity for making a new species, I have concluded to place this shell with the *læviuscula* group provisionally. Inferior specimens of probably the same variety are met

with chiefly in the lower beds, and have already been placed by Blake and Hudleston, provisionally, in the same category.

The specimen figured is the largest and best preserved of any known to me. It is plano-convex (scarcely tumid), suborbicular, and nearly equilateral, with broad, radiating costulæ, smooth above, but rougher, and with more tendency to rise into ridges below. The interstitial sulci, narrow above, but widening out towards the lower margin, are transversely punctato-striate to about the middle of the shell, below which these markings disappear—perhaps owing to an imperfection of fossilization. Being somewhat obscure, they are not shown in the figure.

LIMA cf. GRANDIS, Rœmer. Pl. vi, fig. 19.—The markings on the sulci would seem to connect our shell with *L. rigida*, Sow., but its ribbing and mode of growth are altogether so different that we must either find another name for it, or give it a new one. Rœmer's description of *L. grandis* suits our shell better than his figure does, the chief difficulty being as to the markings of the sulci.

The specimen figured is a very fine one, but I have seen some others nearly as good. It is plano-convex, obliquely semicircular, shortened anteriorly; with flattened, closely set, narrow costulæ, separated towards the lower margin by wider sulci. In the anterior portion of the shell the sulci are always wider, and the intervening costulæ by consequence thinner and sharper. The transverse striations of the sulci, where visible, are fine and numerous.

EXPLANATION OF PLATES.

PLATE IV.

1*a* Nerinæa visurgis, auct, non Rœm. C.O., Seamer; Reed Coll.
1*b* Nerinæa visurgis, young specimen, C.O., Pickering; my Coll.
2*a* Nerinæa Rœmeri, Goldf. C.R., Ayton; Leck Coll.
2*b* Nerinæa Rœmeri, Goldf. C.O., Ayton; Leck Coll.
2*c* Nerinæa Rœmeri, Goldf. C.R., Langton Wold; my Coll.
3 Nerinæa (cylindrical species). C.R., Langton Wold; my Coll.
4*a* Pseudomelania sp. C.R., Brompton; my Coll.
4*b* Pseudomelania sp., reverse.
5 Trochus, cf acuticarina, Buvig. C.R., Howardian district; Leck Coll.
6 Turbo lævis, Buvig. C.R., Ayton; Leck Coll.
7 Trochus inornatus, Buvig. Passage-beds, Wydale; my Coll.
8 Turbo corallensis, Buvig. C.R., Ayton; my Coll.
9*a* Quenstedtia lævigata, Phil., right valve. C.O., Malton; York Coll.
9*b* Hinge of ditto.
10*a* Q. lævigata, var gibbosa, right valve. C.O., Malton; York Coll.
10*b* Hinge of ditto.

11*a* Q. lævigata, var. elongata, left valve. C.O., Malton; Leck Coll.
11*b* Hinge of ditto.

PLATE V.

12 Cucullæa corallina, Damon. C.O., Pickering; my Coll.
13 Trigonia Blakei, Lycett. Passage-beds, Wydale; my Coll.
14*a* Trigonia snaintonensis, Lyc. Passage-beds, Wydale; my Coll.
14*b* Trigonia snaintonensis, from the Upper Oxfordian of the Ardennes; my Coll.
15*a* Avicula ovalis, Phil. Passage-beds, Appleton; my Coll.
15*b* Avicula ovalis, variety from the C.O., Malton; my Coll.
16*a* Pecten inæquicostatus, Phil., right valve. Corallian, Malton; Reed Coll.
16*b* Opposite valve of same specimen.
17 Lima subantiquata, Rœm. C.R., Settrington; my Coll.

PLATE VI.

18 Lima, species, left valve. C.O., Malton; York Coll.
19 Lima, cf grandis, Rœm., left valve. Coral Shell-bed, Seamer; my Coll.

POSTSCRIPT.—The following notes were hastily put together during a recent inspection of Bean's collection at the British Museum:—

Astarte, species: possibly different to any in the Table.—*Cyprina corallina*, d'Orb.=*Cytheræa maltonensis*, Bean.—*Astarte aytonensis*, Lyc. The specimens in Bean's cabinet were found, according to Dr. Lycett, in the "Calcareous Grit of Ayton." The matrix is sub-oolitic. He compares this shell to *A. compressiuscula* of the Inferior Oolite of the Cotteswolds. Judging from the exterior only, some persons might doubt whether the shell should be referred to this genus.—*Cypricardia corallina*, sp. n. very like the shell so named from the Leck. Coll.—*Corbicella lævis*, Sow.=*C. lucida*, Bean.—*Anomia radiata*, Phil.=*A. inæqualis*, Bean.

A few doubtful points might be cleared up, and one or two additional species noted, from a more careful inspection of Sir Charles Strickland's collection, in some respects the best Corallian collection in this country. The opportunity thus afforded would furnish material for a short palæontological paper, in which the new species of Invertebrata enumerated in the Table—ten in number—could be described and figured.

When studying the Table attention should be drawn to the great abundance of Univalves in Column iii. (Coral Rag), pp. 483, 484, and to the poverty of this sub-formation in the genera and species enumerated at base of Page 485 and on Page 486. Note also the abundance of *Arca* and the absence of *Avicula*.

For further explanation see PALÆONTOLOGY, page [illegible].

Explanation.—Column A denotes beds older than the Corallian in Yorkshire.
B. beds newer than the Corallian in Yorkshire, *e.g.*, Kimmeridge Clay.
I. Lower Calcareous Grit in part, and lower Limestones excepting top shell-bed.
II. Coralline Oolite Group.
III. Coral Rag.
IV. Supracoralline.

v. c. Very common. c. common. m. moderately plentiful. l, locally abundant. r. rare. v. r., very rare.

Genus—Species.	A.	I.	II.	III.	IV.	B	*Localities and Remarks.*
Pleiosaurus teretidens, Owen MS.	—	r	r	•	—	—	l. cf. *P. brachydeirus*, Owen—Teeth in C. R. of Grimston; rarer in Malton Oolite.
Teleosaurus sp. *(probably undescribed)* ...	—	•	•	—	—	—	r. Lower jaw in York Mus.—Teeth found sparingly.
Dakosaurus, sp. *(probably undescribed)* ...	—	•	•	?	—	—	r. Teeth found sparingly.
* Megalosaurus ? Bucklandi, Meyer	—	—	•	—	—	—	v.r. Specimen of tooth in white oolite, York Museum.
Sphærodus, sp. *(probably undescribed)* } ? ..	—	—	•	—	—	—	l. "eyes" of the Malton quarrymen.
Pycnodus, cf. umbonatus, Ag. } ..	—	—	•	—	—	—	v.r. British Museum, Bean Coll.
Gyrodus, sp.	—	—	?	—	—	—	v.r. One palate in Leck. Coll.—apparently in Malton Oolite.
Hybodus, cf. grossiconus, Ag.	—	•	r	?	—	—	l. Chiefly from calc grits of Appleton, and Birdsall.
,, obtusus, Ag.	—	—	—	•	—	—	r. C. R. of Grimston—Found at Wheatley, near Oxford.
Asteracanthus ornatissimus, ? Ag.	—	?	—	—	—	—	v.r. One spine in my Coll.—locality unknown.
Belemnites abbreviatus, Mill. var. *a.*	r	•	r	—	—	—	c. Chiefly in the L. C. G., very stout short form.
,, ,, var. *b.*	—	—	•	?	—	—	c. A modification of the above, chiefly in the C. O. Some of these doubtless include *B. excentralis*, Y. & B.
,, ,, var. *c.*	—	—	—	?	•	?	l. A very marked form occurring in the supracoralline.
,, nitidus, Dollf.	—	—	—	—	•	*	r. In the U. C. G., but characteristic of the lower K. C., = *B. explanatus*, Phil.
,, cf. Owenii, Pratt	—	—	•	—	—	—	r. These narrow forms occur in C.O., at Malton and Settington.

* N.B. The Museum of the Yorkshire Philosophical Society contains the bones of a very large Saurian from the Corallian of Slingsby; also fragments of bone referred to *Ganodus*.

Genus—Species.	A.	I.	II.	III.	IV.	B.	*Localities and Remarks.*
Belemnites hastatus, Mont.	•	•	?	—	—	—	m. Small forms referred here occur chiefly in the lower beds.
" ? semisulcatus, Münst.	—	—	—	—	•	—	v.r. One specimen from the Cement-stone, N. Grimston.
Nautilus hexagonus Sow.	•	•	•	—	—	—	m. Chiefly in the gritty Passage-beds. Attains a great size.
" aganiticus, Schlot.	—	—	—	•	—	—	v.r. One specimen found in the top of the C. R., Grimston Field.
Ammonites (Aspidoceras) perarmatus, Sow. var. *a.*	•	•	—	—	—	—	m. Rounded thick-whorled form with large spikes, L. C. G. of coast.
" var. *b.*	—	•	?	—	—	—	m. Sides more compressed; spikes less prominent (type). Lower Limestones.
" var. *c.*	—	—	—	•	—	?	v.r. Single specimen from Sike-Gate, showing connection with *A. longispinus*, Sow.
" (Perisphinctes) Williamsoni, Phil.	?	•	—	—	—	—	r. Passage-beds of Scarborough district: near to *A. arduennensis*, d'Orb.
" " convolutus, Quens.	•	•	—	—	—	—	m. The representative of *A. plicatilis* in the lower beds.
" " plicatilis, Sow.	—	—	•	—	—	—	c. Upper Passage-beds, Pickering, and C. O. generally.
" " varicostatus, Buckl.	—	—	—	•	•	?	m. Chiefly C. R. at Hildenley and N. Grimston.
" " cf. Achilles, d'Orb.	—	—	—	—	•	—	m. A compressed "biplex" form, chiefly in the U. C. G.
" " cf. decipiens, Sow. pl. 294.	—	—	—	—	•	•	l. A triplicate form from the U. C. G. of Kirkdale cutting.
" Berryeri, Lesueur.	—	—	—	—	•	•	l. Allied to *A. cymodoce*, d'Orb., U. C. G. Kirkdale.
" (Amaltheus) cordatus, Sow.	•	•	•	—	—	—	v.c. *A. excavatus*, Sow., in the adult stage.
" " vertebralis, Sow.	•	•	•	—	—	—	v.c Perhaps *A. goliathus*, d'Orb., in the adult stage.
" vertebralis, var. Cawtonensis, Bl. & H.	—	—	—	•	—	—	l. A variety found in the C. R., Sike-Gate, and urchin beds, Grimston.
" " alternans, Von Buch.	—	—	—	—	•	?	m. The representative of the Cordati in the Supracoralline Beds. Pickering, &c.
" (?) Sutherlandiæ, Sow.	•	•	—	—	—	—	r. A name doubtfully applied to a distinct form in the lower beds.
Purpuroidea nodulata, Y. & B.	—	—	—	•	—	—	m. C. R. of the Howardians. Near to *P. Lapierrea*, Buvig.; differs from any of the Minchinhampton sp.
" sp ?	—	—	—	•	—	—	r. C. R. of Howardians.

Genus—Species.	A.	I.	II.	III.	IV.	B.	Localities and Remarks.
Natica globosa, Rœm.				*	—		m. C. R. of the Howardians. Cf. also *N. grandis*, Münst., (d'Orb., pl. 295).
„ clytia, d'Orb.				*	—		c. C. R. of the Howardians. ? Ayton } These forms seem to run into each other.
„ Clymenia, d'Orb.				*	—		m. In situations similar to the preceding. } These forms seem to run into each other.
„ ? arguta, Phil.				*	—		r. Fine specimen from Slingsby in the Leck Coll.
Chemnitzia heddingtonensis, Sow.		?	*	*	*		v.c. C. O. everywhere, less common in C. R., where the form is rather different.
„ Pollux, d'Orb.				*	—		v.r. C. R. of Langton Wold, and ? Helmsley.
„ langtonensis, Bl. & H.				*	—		v.r Single specimen from the C. R. of Langton Wold.
Pseudomelania striata, Sow.	?		*	*	—		v.c. Frequent in C. R. of Ayton, &c., and in C. O. of Pickering and Malton.
„ Buvignieri, d'Orb.			*	*	—		r. C. R. of Ayton, C. O. of Nawton. The *Phasianella elegans* of some collections.
„ species.				*	—		v.r. C. R. of Brompton. A short form with rounded whorls. Pl. iv., fig. 4.
„ calypsoides, Thurm.				*	—		v.r. ? C. R of Ayton—Scarborough Museum—as a *Nerinæa* in Thurm. & Étallon. (Pl. vi., fig. 20.)
„ sp.		*		—	—		v.r. A small form from the shell-bed at Wydale.
Cerithium muricatum, Sow.	*	*	*	—	—		c. Chiefly the shell-beds of C. O., rare in L. C. G., not found in C. R.
„ limæforme, Rœm.			*	*	—		m. Chiefly in the C. R. of Ayton, &c., Sparingly in the Oolites.
„ inornatum, Buvig.			*	*	—		l. Plentiful in the C. R. of Ayton, &c.
„ cf. Humbertinum, Buvig.				*	—		v.r. C. R. of Ayton and the neighbourhood—Scarborough Museum.
„ cf. virdunense, Buvig.			*	—	—		r From a shell-bed containing small univalves at Ness—doubtful identification.
„ Michaelense, Buvig.				*	—		v.r. Single specimen, C. R., Sproxton, Blake Coll.
„ sp. n. (*bicinctum*)				*	—		v.r. Single specimen in Leck. Coll., "Malton."
Nerinæa fusiformis, d'Orb.			*	*	—		l. Very abundant in C. R., Brompton. ? C. O., Pickering.
„ Clymene, d'Orb.				*	—		r. A stouter variety of this peculiar group of *Nerinæa*, C. R., Ruston.

Genus—Species.	A.	I.	II.	III.	IV.	B.	*Localities and Remarks.*
Nerinæa visurgis, Auct., non Rœm.	—	—	•	—	—	—	1. *N. visurgis* of most collections. C. O. Ayton, &c. Base of C. O. Pickering. Pl. iv., fig. 1.
„ Rœmeri, Philippi, (Goldf.) ...	—	?	•	•	—	—	c. *N. fasciata* of some collections. C. R. Ayton. C. O. Malton, &c. Pl. iv., fig. 2.
„ "allongiuscula," Bean.	—	—	—	•	—	—	r. C. R. Langton Wold. Pl. iv., fig. 3.
Alaria bispinosa, Phil.	•	•	—	—	—	—	m. Found chiefly in the L. C. G. of the coast.
„ cf. tridactyla, Buvig. (De Lor.)	—	—	—	•	—	—	v.r. Noticed by Mr. Blake in the urchin beds of N. Grimston.
„ sp.	—	—	—	•	—	—	v.r. One specimen, C. R. Hovingham.
Pterocerus ? sp.	—	—	—	•	—	—	v.r. One specimen (cast), urchin beds, N. Grimston.
Littorina Meriani, Goldf.	?	•	•	—	—	—	r. The difference between these three forms is slight, yet fairly recognisable. *L. muricata* is a little beehive form; the others are larger, but not nearly so fine as the figured specimens.
„ muricata, Sow.	—	—	?	•	—	—	v.c.
„ ? pulcherrima, Dollf.	—		—	•	—	—	c.
„ (Eucyclus) Buvignieri, d'Orb. ..	?	—	—	•	—	—	r. C. R. of Ayton and Langton Wold.
„ „ princeps, Rœm. ..	—	—	—	•	—	—	v.r. C. R. of the Howardians, *e.g.* Hildenley—Colls. Strickl. and Reed.
Nerita, sp.	—	—	—	•	—	—	r. Casts from C. R., N. Grimston.
Neritopsis Guerrei, Héb. & Desl.	—	—	—	•	—	—	v.r. C. R. of the Howardians—Colls. Strickl. & Leck.
„ ? sp.	—	—	—	•	—	—	v.r. Possibly another species of *Neritopsis*. Strickl. Coll.
Turbo funiculatus, Phil.	—	—	?	•	—	—	m. Most frequent in the C. R., Ayton, Brompton, and Langton Wold; rare in C. O.
„ corallensis, Buvig.	—	—	—	•	—	—	m. The *Nerita lævigata* of Bean's identification. Ayton, &c. Grimston.—Pl. iv., fig. 8.
„ lævis, Buvig. (? = T. Erinus, d'Orb., Prod. ii., 9.)	—	—	—	•	—	—	v.r. Single specimen in Leck. Coll. C. R. of Ayton, &c. (*i.e.* of Scarborough district).—Pl. iv., fig. 6.
Trochus aytonensis, Bl. & H.	—	—	•	•	—	—	r. C. R. of Ayton, &c; Shell-bed at base of C. O. Pickering.
„ cf. Michaelensis, Buvig.	—	—	—	•	—	—	v.r Single specimen from C. R. Brompton.
„ cf. acuticarina, Buvig.	—	—	—	•	—	—	v.r. C. R. of Howardian district; Leck. Coll.—Pl. iv., fig. 5.
„ sp. n. (*granularis*)	—	—	•	—	—	—	v.r. Single specimen; shell-bed at base of C. O., Pickering; Leck. Coll.
„ inornatus, Buvig. . .	—	•		—	—	—	v.r. Shell-bed in Lower Limestones, Wydale.—Pl. iv., fig. 7.

						described from "Sequanien" of Boulogne.
" muricata, Buvig.	—	—	—	*		r. C. R. of Ayton—Brompton. Strickl. Coll.
Pleurotomaria Münsteri, Goldf.	*	*	*			m. Base of the whorl less bicarinated than in succeeding species.
" reticulata, Sow.	—	—	—	*		r. C. R. of the Howardians. Originally described from K. C.
" Agassizi, Münst.	—	—	—	*		v.r. Single specimen in Leck. Coll., from C.R. of the Howardians.
Trochotoma tornata, Phil.	—	—	—	*		c. ? = *T. discoidea*, Buvig. Characteristic of C. R. throughout.
Patella, cf. Mosensis, Buvig.	—	—	—		*	v.r. Single specimen from U. C. G., Pickering.
Dentalium entaloideum, Desh.	*	*	—			c. L. C. G., and Lower Passage-beds of coast.
Bulla Beaugrandi, de Lor.	—	—	—	*		v.r. Single specimen from the quarry east of Ayton.
Cylindrites elongata, Phil.	—	*	?			v.c. Characteristic of the Lower Limestones, especially of the Scarborough district.
" (Acteonina) retusa, Phil.	—	r	—	*		r. C. R. both of Scarborough and Howardian districts. ? L. C. G.—specimen in York Mus.
" " ? Lhuidii, Whit.	—	—	—	*		r. C. R., Ruston.
Gastrochæna Moreana, Buvig.	—	—	—	*		o. C. R., especially at Brompton. ? = *Pholas recondita*, Phil. A coral borer.
Gresslya peregrina, Phil.	*	*	—			r. Passage-beds. Scarborough Castle.
Goniomya litterata, Sow.	*	*	*		*	m. L. C. G., Oliver's Mount. Upper Limestones of Filey, and many other places.
" v.—scripta, Sow.	*	—	—	*		m. C. R. of N. Grimston and elsewhere.
" marginata, Ag.	—	—	—		*	l. Perhaps some of the Supracoralline specimens may be referred here.
Myacites (Pleuromya) tellina, Ag.	—	—	—		*	l. } The numerous Myacites of the U. C. G., Pickering, are referred here.
" " Voltzii, Ag.	—	—	—		*	l. }
" " jurassi, Brong.	*	*	*			c. Not far from *M. decurtatus*, Phil. } Several obscure and ill-preserved forms are included here.
" " recurvus, Phil.	*	*	*			c. Near to *M. obliatus*, Sow. }
Pholadomya decemcostata, Rœm.	—	—	*			m. Upper Limestones of Filey point, and elsewhere.

Genus—Species.	A.	I.	II.	III.	IV.	B.	*Localities and Remarks.*
Pholadomya æqualis, Sow.	—	—	?	—	—	—	m. Oolites and Limestones of uncertain position.
„ cf. concentrica, Rœm.	—	—	—	—	*	—	r. The Cement-stone of N. Grimston.
„ parcicosta, Ag.	—	*	*	—	—	—	m. Oolitic Limestones of Malton district; exact position unknown.
Homomya tremula, Buvig.	—	—	*	*	—	—	r. Large casts occur at Malton in white oolite, and in soft rag at Grimston.
„ sp. n. *(grimstonensis)*	—	—	—	*	—	—	v.r. One specimen, C R., North Grimston.
Thracia incerta, Thurm., or depressa, Sow.	—	*	—	—	*	?	m. Uncertain if specimens from L. C. G. of coast are same as those from Cement-stone.
Solemya sp.	—	?	—	—	—	—	v.r. Fine specimen, probably from Appleton, in Bowerbank Coll.
Anatina undulata, Sow.	*	*	*	—	—	—	r. Lower Passage-beds, Appleton. Upper P. B. Pickering, Bowerbank Coll.
Quenstedtia lævigata, Phil.	*	—	*	—	—	—	m. Type form: chiefly Malton Oolites—Pl. iv., fig. 9. (A pair of small *Quenstedtia*, from the Scarborough district, in Leck. Coll., may be young of some of these.)
„ „ var. elongata.	—	—	*	—	—	—	r. C. O. Malton. Leck. and Beed. Colls.—Pl iv., fig. 11.
„ „ var. gibbosa.	—	—	*	—	—	—	v.r. York Museum.—Pl. iv., fig. 10
Sowerbya (Isodonta) triangularis, Phil.	—	*	*	—	—	—	c. Specially abundant in the small Shell-bed, Pickering.
„ „ Deshayesea, Buvig.	*	*	—	—	—	—	r. Occurs in Shell-bed, Wydale. N.B. Whiteaves' figure does not represent Buvignier's species.
Cyprina corallina, d'Orb.	—	—	*	—	—	—	r. *Trigonia*-beds, Pickering. C. O., Malton.
Astarte ovata, Smith.	—	—	*	*	—	—	v.c. Chiefly upper part of C. O. and C. R. of the Howardians.
„ „ var. cf. Michaudiana, Dollf.	—	—	—	?	—	—	r. Specimen in York Museum.
„ Duboisiana, d'Orb.	—	*	*	—	—	—	l. Small in the L. L. Larger and more abundant in C. O. at Ayton, &c. Representative of *A. elegans*.
„ „ sp. n. *(æquilatera)*	—	—	*	—	—	—	v.r. Malton Oolite. York Museum.
„ depressa, Münst.	—	—	*	—	—	—	r. Top bed of L. L., Newtondale, and Oolite of Swinton.
„ sp. n. *(megalomorpha)*	—	*	—	—	—	—	l. Passage-beds of Scarborough district. Immense specimens at Wydale.
„ extensa, Phil.	—	*	r	—	—	—	c. Lower beds of Scarborough district. Abundant at Wydale. [illegible] percrassa, Et

Genus—Species.	A.	I.	II.	III.	IV.	B.	*Localities and Remarks.*
? Astarte aytonensis, Lyc.	—	—	—	?	—	—	v.r. A form similar to that figured by Lycett occurs in the C. R. Upware, Cambs.
„ rhomboidalis, Phil.	—	*	—	*	—	—	c. Chiefly C. R. of the Howardians; a dwarf variety in the L. C. R., Hackness.
Isocardia tenera, Sow. (tumida, Phil.)	*	*	—	—	—	—	c. More abundant in the L. C. G. than in the Passage-beds.
Cypricardia glabra, Bl. & H.	—	*	—	—	—	—	r. Shell-bed, Nawton small shell-bed, Pickering.
„ isocardina, Buvig.	—	—	*	*	—	—	m. Probably the *Cardium lobatum*, Phil.; chiefly C. R. of the Howardians.
„ sp. n. (*corallina*)	—	—	*	—	—	—	v.r. Single specimen, Leck. Coll. *Trigonia*-beds, Pickering.
„ ? sp.	—	*	—	—	—	—	l. Casts of a small *Cypricardia* occur in the L. C. R. of Hackness.
Opis Phillipsi, Morr.	—	?	*	*	—	—	m. Small species having intermediate forms which seem to connect them.
„ corallina, Damon.	—	—	*	*	—	—	m. (see above)
„ virdunensis, Buvig.	—	—	—	*	—	—	r. C. R. of Langton—Grimston (Howardians). Very abundant at Upware, Cambs.
„ lunulata, Roem.	—	—	—	*	—	—	v.r. C. R. of Grimston, Strickl. Coll.
Myoconcha texta, Buvig.	—	—	—	*	—	—	r. C. R. of Ayton, Brompton, &c. Figured by Buvignier as a *Mytilus*.
„ Sæmanni, Dollf.	—	—	*	—	—	—	v.r. Specimen in Reed Coll. from Malton Oolite may be referred here.
Lucina aliena, Phil.	—	—	*	—	—	—	v.o. Coralline Oolite generally, especially about Malton.
„ globosa, (Beanii) Buvig.	*	—	*	—	—	—	v.o. Nearly allied to the preceding; abundant rather lower down.
„ oculus, Bl. & H.	—	—	*	r	—	—	r. Chiefly in C. O., Malton, Nawton, Ampleforth. One specimen C. R. Ruston.
„ Moreana, Buvig.	—	—	*	—	—	—	r. Near to the preceding species, Nawton, Ampleforth, &c.
„ substriata, Roem.	—	—	*	—	*	—	m. Occurs in the C. O. at Nawton, but more frequently in U. C. G., Pickering.
„ cf. aspera, Buvig.	—	—	—	*	*	—	c. Very characteristic of the U. C. G., Pickering, and Cement-stone, N. Grimston.
„ lirata, Phil.	*	*	*	—	—	—	m. Chiefly in the calc grits, Passage-beds and limestones of the coast.

Genus—Species.	A.	I.	II.	III.	IV	B.		*Localities and Remarks.*
Lucina ampliata, Phil.			*				l.	Oolites of the Malton district only.
Corbicella Buvignieri, Desh.			*				r.	Fine large shells, found sparingly in the Malton Oolites. York Mus. and Leck. Coll.
„ decussata, Buvig.			*				r.	
„ lævis, Sow.			*				m.	
„ sp., with mesial umbones.				*			r.	Clearly different to any of the others. York Mus.
Tancredia curtansata, Phil.	*		*				r.	Originally figured by Phillips, from C. O. of Malton district.
„ cf. planata, M. & L.			*				r.	Oolite of Setterington; "small shell-bed," Pickering.
Unicardium (Sphæra) depressum, Auct.			*				r.	"Rabbit-eye," Malton; "small shell-bed," Pickering; C. O., Ampleforth.
„ „ plenum, Bl. & H.			*				r.	Leck. Coll. Malton Oolite.
„ „ sp.			*				v.r.	Single specimen from the C. O. of Ness.
Cardium cyreniforme, Buvig			*				r.	"Small shell-bed," Pickering.
„ cf. delibatum, de Lor.					*		r.	A distinctly marked *Protocardium*, U. C. G., Pickering.
Trigonia Meriani, Ag.			*				r.	Fine specimens obtained from C. O., Malton, v.r. in *Trigonia*-beds, Pickering.
„ (costate) sp.				*			r.	C. R. of Sike Gate, and sparingly elsewhere.
„ clavellata, Sow.		*					m.	Specimens from L. C. G., and Passage-beds referred here by Dr. Lycett.
„ ? Bronnii, Ag.		*					v.r.	One specimen from Oliver's Mount; not the *T. Bronnii* of Glos near Lisieux in France.
„ perlata, Ag. (as identified by Lycett)			*				v.c	*Trigonia*-beds (Upper Passage-beds), Pickering. C. O. generally.
„ ? Voltzii, Ag.					*		v r.	One specimen, U. C. G, Pickering.
„ triquetra, von Seeb.		*					r.	In the lower beds at Filey, and ? Scarborough.
„ snaintonensis, Lyc.		*					l.	Plentiful in the shell-bed at Wydale. Appleton. Pl. iv, fig. 14.
„ Blakei, Lyc., sp. n.		*					v.r.	Single specimen, shell-bed, Wydale. Pl. v, fig. 18.
Nucula, sp.					*		r.	Cement-stone, N. Grimston
Arca pectinata, Phil.				*			o.	C R. throughout; also in the Coral Shell-beds.
„ quadrisulcata, Sow.				*			o.	C. R. throughout
„ æmula, Phil. (? Mosensis, Buvig.)				*			r.	Shell-bed, Wydale (if same). C R. of the Howardians.
„ cf. Langei, Thurm.							r	A doubtful form occurring in C. R. of Ayton.
„ lanthanon, Bl & H.							v r.	Single specimen, C R., Slingsby. Blake Coll.

Genus—Species.	A.	I.	II.	III.	IV.	B.		*Localities and Remarks*
Cucullæa corallina, Damon.	—	r	•	—	—	—	m.	Mostly in *Trigonia*-beds, Pickering. Pl. v, fig. 12.
" elongata, Phil., non Sow.	—	—	•	•	—	—	m.	Resembles *C oblonga*, Sow. Seems to replace *C. corallina* in the higher beds.
Limopsis corallensis, Buvig.	—	—	•	—	—	—	r.	"Small shell-bed," Pickering. Blake Coll.
Mytilus ungulatus, Y. & B.	—	—	•	•	—	—	m.	*Trigonia*-beds, Pickering, and C. R. of the Howardians.
" ? jurensis, Merian.	—	•	—	—	—	—	r.	L. C. G., and Passage-beds, Filey.
" pectinatus, Sow.	—	—	•	—	—	—	v.r.	Single specimen, Westendarp Coll., obtained at Malton.
Modiola bipartita, Sow.	•	•	-	—	—	—	c.	Characteristic of the L. C. G., but scarcely ascends into L. L.
" subæquiplicata, Goldf.	—	—	•	•	—	—	r.	Occurs in C. O; and in soft parts of C. R., Syke Gate—variety of the preceding.
" cancellata, Rœm.	?	—	—	•	•	—	r.	Found in C. R. at Grimston and Hildenley—U. C. G., Nunnington cutting.
" inclusa, Phil. (Coral Borers.)	—	•	•	•	—	—	v.c.	Wherever there is coral. Especially common in C. R.
" Lycetti, Whit. (Coral Borers.)	—	—	—	•	—	—	r.	C. R. of Ayton, Brompton, &c.
" sp. n. (*gibbosa*). (Coral Borers.)	—	—	—	•	—	—	v.r.	Single specimen, Leck Coll., probably C. R. of Howardians.
Pinna lanceolata, Sow.	•	•	r	—	r	—	c.	Chiefly in the L. C. G. proper. *Pinna* of the Supracoralline-beds may be different.
Trichites. ? Plotii, Lhwyd.	—	•	•	•	—	—	m.	L. L. Crompton. C. O. Malton. C. R. North Grimston.
Gervillia aviculoides, Sow.	•	•	•	—	—	—	v.c.	Passage-beds and L. L., Crompton and elsewhere; Upper Limestones, Filey, Pickering, &c.
" angustata, Rœm.	—	—	•	—	•	—	r.	"Small shell-bed," Pickering, U. C. G., Kirkdale cutting.
Perna mytiloides, Lam.	—	•	•	r	—	—	m.	When very large, as in the Malton oolite, resembles *P. rugosa*, Goldf.
" subplana, Ét.	—	—	—	•	—	—	r.	Found in the great Shell-bed of the C. R., North Grimston.
" sp. n. (*inoceramoides*)	—	—	•	—	—	—	v.r.	Single specimen in Malton oolite; York Museum.
Avicula pteropernoides, Bl. & H.	—	—	•	—	—	—	v.r.	Top of the L. L., Thornton.—A specimen in Bowerbank Coll. possibly from L. C. G.
" Struckmanni, de Lor.	—	—	•	—	—	—	v.r.	Single specimen (cast): top of L. L., Newtondale.
" Braamburiensis, Phil.	•	•	—	—	—	—	l.	L. C. G. of Oliver's Mount.
" expansa, Phil.	•	•	•	—	—	—	c.	A megalomorph of a very persistent Jurassic form. Appleton and elsewhere.

Genus—Species.	A.	I.	II.	III.	IV.	B.	*Localities and Remarks.*
Avicula inæquivalvis, Sow.	•	—	•	?	—	—	m. Generally associated with, and nearly the same as the preceding.
" ovalis, Phil.	?	•	•	—	—	—	o. The finest shells occur in the P. B., Appleton; a different type in the C. O.—Pl. v, fig. 15.
" " var. obliqua, Bl. & H.	—	—	—	—	•	—	r. U. C. G., Pickering—diverges still further from the large forms at Appleton.
" lævis, Bl. & H.	—	•	—	—	—	—	r. L. L. Kepwick and Cropton.
" elegantissima, Bean. ? Corallian. ...	—	?	—	—	—	—	v.r. Single specimen in York Mus. Matrix might be Passage-bed rock.
" ædilignensis, Bl.	—	—	—	?	—	•	v.r. A doubtful specimen, C. R. Grimston; v.c. in K. C., Hildenley.
Lima læviuscula, Sow., var. *a*.	—	—	•	—	—	—	l. Sowerby's type; principally Malton Oolites.
" " *b*.	—	—	—	•	—	—	l. A smoother form, characteristic of the great shell-bed, C. R., North Grimston.
" " *c*.	—	•	•	—	—	—	m. Belongs to the *læviuscula* group, but is far coarser in the ribbing. Pl. vi, fig. 18.
Lima cf. grandis, Rœm.	?	—	•	•	—	—	r. Coral Shell-bed, Seamer. Malton Oolite. Pl. vi, fig. 19.
" rigida, Sow.	—	—	•	•	—	—	c. Principally C. O. and C. R. of the Howardian district.
" ? densepunctata, Rœm.	—	—	—	•	—	—	l. Species with very fine lines. C. R. of Ayton, &c.
" subantiquata, Rœm.	—	—	•	•	—	—	r. C. O. of Malton. C. R. Settrington Grange. Pl. v, fig. 17.
" { pectiniformis, Schlot.	•	—	—	•	—	—	v.c. } Throughout the C. R. generally. Has a wide range throughout the oolites.
" { rudis, Sow., dwarf var.	—	•	—	•	—	—	o }
" gibbosa, Sow.	?	•	—	—	—	—	r. "Red beds" of the Scarborough district. Like the Inferior Oolite form.
" elliptica, Whit.	—	•	•	—	—	—	m. L.L., Kepwick, C. O. Pickering, Malton.
" sp. near to elliptica	—	—	—	•	—	—	r. C. R., Langton Wold and North Grimston.
Pecten lens, Sow.	•	?	•	•	—	—	c. Left valves of this sp. named *P. arcuatus* in some collections.
" ? comatus, Münst.	?	—	—	•	—	—	r. C. R., Ayton in Jermyn St. Mus. N.B. *P. comatus* was described from the black "Jurakalk."
" vimineus, Sow. (near articulatus, Schlot.)	?	•	•	•	•	—	v.c. Always abundant in the C. R. Fine specimens from C. O., of Malton.

Genus—Species.	A.	I.	II.	III.	IV.	B.	*Localities and Remarks.*
Pecten demissus, Phil.	•	—	•	•	—	—	r. Malton. Settrington *P. climatus*, Bean—B. Mus.
„ intertextus, Rœm.	•	—	•	•	—	—	m. Magnificent specimens from C. O , Malton, &c., and C. R., Langton *P. cancellatus* of Bean.
„ fibrosus, Sow.	•	•	•	—	—	—	v.c. includes *P. subfibrosus*, d'Orb. ; and *P. vagans*, Sow., in part.
„ inæquicostatus, Phil.	•	—	•	•	—	—	m. C. O. of Malton, Settrington, C. R., Langton Wold. Pl. v, fig. 16.
„ qualicosta Ét.	—	—	•	—	—	—	r. C. O. of Settrington.
„ Midas, d'Orb.	—	—	—	—	•	—	m. The representative of the *P. fibrosus* group in the higher beds.
Hinnites cf. velatus, Goldf.	—	—	•	•	—	—	m. C. R. of Ayton, Brompton, &c. "Small shell-bed," Pickering.
„ sp n. *(corallina)**	—	—	—	•	—	—	c. Characteristic of the C. R. throughout England ; common at Grimston.
Plicatula fistulosa, M. & L.	—	—	—	•	—		r. C. R., Brompton, Seamer, Ayton.
„ sp n. *(subinflata)*	—	—	—	•	—	—	v.r. C. R. Brompton.
„ or Spondylus, sp.	—	—	•	•	—	—	r. C. R., Ayton, &c. ; base of C. O., Pickering.
Anomia radiata. Phil.	•	—	•	•	—	—	c. Attains a great size in the C. R., N. Grimston.
Ostrea duriuscula. Phil.	—	—	•	•	—	—	v.c. Principally in the C. R. A comprehensive species.
„ Moreana, Buvig.	—	—	—	•		—	r. C. R Nunnington cutting and elsewhere.
„ bullata, Sow.	—		•	—	•	–	l. Large variety, Filey Brigg Calc Grit ; smaller ditto, Supracoralline beds.
„ (Gryphæa) dilatata, Sow.	•	•	?	—	—	—	c. L. C. G and Lower Passage beds ; type form, rare in C. O.
„ subgibbosa, Bl. & H.	—	—	—	—	•	—	l. Cement-stone, N. Grimston ; closely allied to the preceding.
„ (Exogyra) nana. Sow.	•	•	•	•	•	•	v.c. Includes the *Ex. mima*. Phil.
„ „ cf. spiralis, Goldf. ...	•	•	—		—	—	r. Some of the forms in the lower beds, *e.g.* L. C. R., Hackness.
Ostrea, var. of flabelloides, Lam.	•	•	—	—	—	—	m. Lower Passage-beds at Scarborough and Filey.
„ gregaria, Sow.	—	•	—	•	—	—	c. C. R. everywhere. L. C. R., Hackness.
„ ? solitaria.	–	?	•	•	—	—	r. C. R., Ayton, *Trigonia*-beds, Pickering.
Terebratula fileyensis, Walk	—	•	—	—	-	—	l. L. C. G., Scarborough ; but most plentiful in P. B., Wydale, Filey, &c.

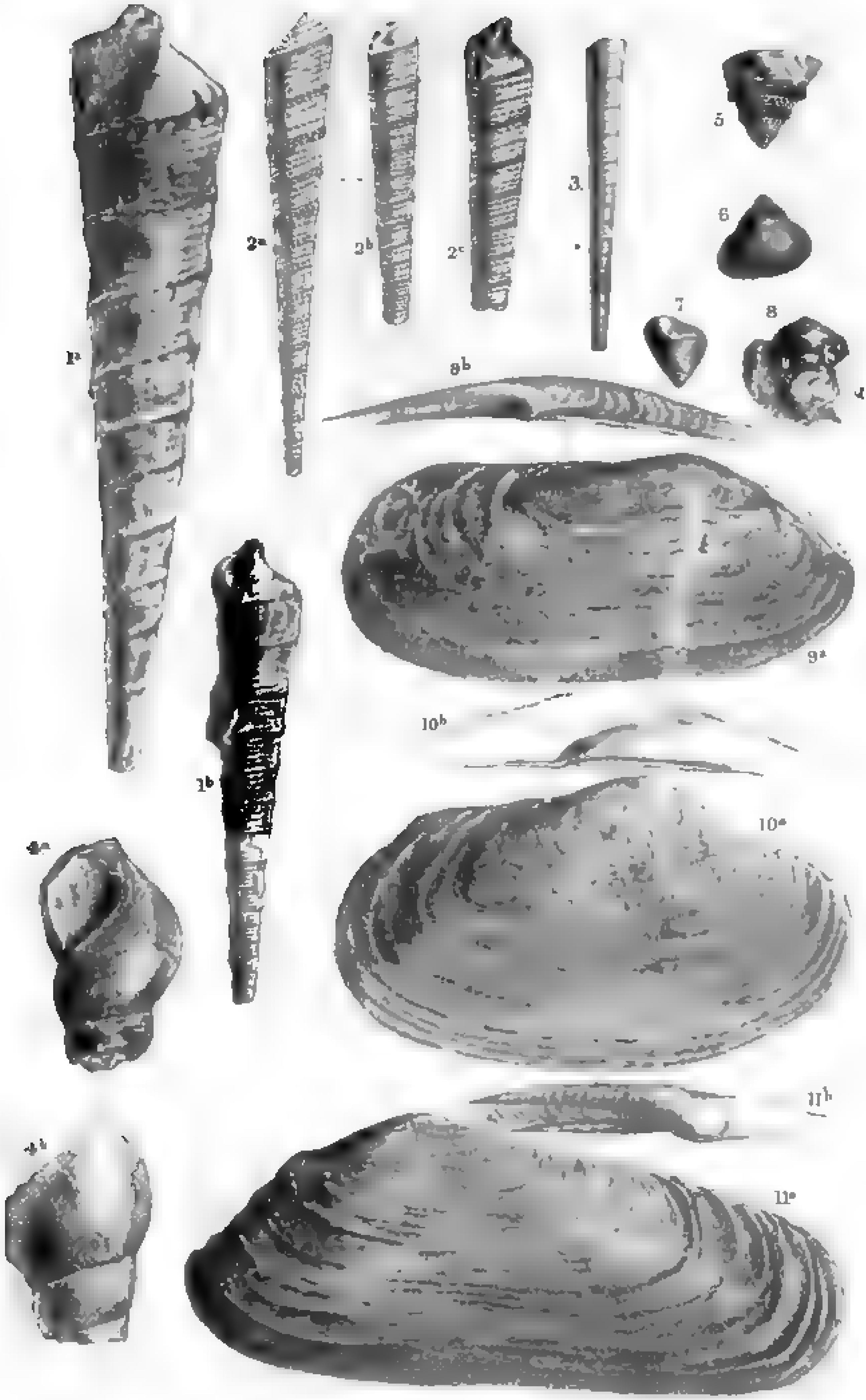
* The nearest figured form is *Hinnites fallax*, Dollf.

Genus—Species.	A.	I.	II.	III.	IV	B.	*Localities and Remarks.*
Terebratula insignis, Schübl.	—	—	—	*	-		r. C. R. of Howardians, Oswaldkirk, Helmsley; var. ***Maltonensis***, Oppel.
" Boloniensis, R. & S.	—	—	—	*	-		v.r. Single specimen in Leck. Coll. C. R. of the Howardians.
Waldheimia buccolenta, Sow.	?	*	—	—	-		v.r. Passage-beds, Appleton.
" Hudlestoni, Walk.	—	*	—	—	-		l. Abundant in the L. C. R., Hackness; Lower P. B., Filey; Wydale.
" margarita, Opp.	—	—	—	*	-		l. Not rare in the C. R., Ayton. Previously quoted as *T. insignis* (juv.)
Rhynchonella lacunosa, Schlot.	—	*	?	—	-		v.r. L. C. G., Oliver's Mount, "Red beds," Beedale. ? Pickering.
" Thurmanni, Voltz.	?	*	—	—	-		v.c. L. C. G. throughout, and base of L. L., *i.e.*, the Passage-beds
Diastopora ? diluviana, Edw.	*	*	—	—	-		v.r. One specimen on *Astarte*, Wydale.
Cidaris Smithii, Wright.	—	*	r	*	-		v.c *i.e.* The spines. Has a wider range than *C. florigemma*.
" sp.	—	—	—	*	-		v.r. A very long spine in the Leck. Coll. may belong to another species.
" florigemma.	—	—	r	*	-		v.c. *i.e.* The spines. Characteristic of the C. R., except of the Scarborough District.
Hemicidaris intermedia, Flem.	—	-	—	*	-		c. C. R. everywhere, test and spines.
Pseudodiadema versipora, Phil	—	*	—	*	-		c. Abundant in the C. R. of Ayton, &c.
" hemisphæricum, Ag.	—	-	—	*	-		l. C. R. of Howardian Hills only, most abundant at N. Grimston.
*Hemipedina corallina, Wright	—	—	—	?	-		v.r. A single fragment obtained by Bean from Malton.
Glypticus hieroglyphicus, Goldf.	—	—	—	*	-		r. C. R., Nunnington and Hovingham.
Stomechinus gyratus, Ag.	—	—	—	*	-		r. C. R., Nunnington, North Grimston.
Acrosalenia decorata, Haime	—	*	—	—	-		l. The specimens known to me are from the Passage-beds (L. L.) of the coast.
Holectypus depressus, Leske	*	*	*	?	-		c. The specimens are usually small. } Usually too defaced for specific determination.
" sp. (? oblonga, Wr.)	—	—	—	*	-		r. ? also *H. corallina*, d'Orb. } Usually too defaced for specific determination.
Pygaster umbrella, Ag.	—	—	*	*	-		m. Chiefly in the Howardians.

* This species is inserted entirely on the authority of Dr. Wright in the Palæontographical.

Genus—Species.	A.	I.	II.	III.	IV	B.	*Localities and Remarks.*
Collyrites bicordata, Leske		•		•		—	m. Small in the L. C. G., Castle Howard; large in C. R., Hildenley, and Sike Gate.
Echinobrissus, sp.	•	•				—	r. Some forms in the lower beds resemble *Ech. clunicularis*. Scarborough Castle.
„ scutatus, Lam.	•	•	•	•		—	v.c. Especially in the L.L. Specimens from C. R., rare, and far larger.
Clypeus subulatus, Y. & B.			•			—	v.r. "Usually imbedded in a white oolitic limestone," Wright, page 365.
Pygurus pentagonalis, Phil.	?	•	•	•		—	m. Specimens from the L. L. Scarborough smaller than those from C. R. of Hildenley.
„ Hausmanni, K. & D.			•			—	m. Chiefly from L. O. of the Malton district.
Millericrinus echinatus, Goldf.	?	•				—	o. Passage-beds, Filey, Appleton, and many other localities.
„ ? sp.				•		—	r. May be a different portion of stem of preceding. Kirkby Moorside, Whitewall.
Apiocrinus polycyphus, Merian			?	•		—	r. C. R., North Grimston; fine specimen in oolite matrix, York Museum.
Pentacrinus, sp.		•				—	r. Passage-beds, Scarborough, Wydale.
„ sp.				•		—	r. Highest C. R. of N. Grimston, along with *Apiocrinus polycyphus*.
Astropecten rectus, M'Coy		•				—	m. L. C. G. of coast. Plates of this or an allied species occur in the lower shell-beds.
Glyphea rostrata, Phil.	—	•	?			—	l. Plentiful in the L. C. G. and Passage-beds, Appleton, &c.
„ scabrosa, Phil.	?	•				—	r. York Museum.
Serpula squamosa, Phil.		•		•		—	o. P. B., Scarborough Castle; C. R., Langton Wold; ? *S. sulcata*, Sow.
„ tetragona, Sow.	•	•				•	v.r. P. B., Scarborough Castle; similar to form in K. C.—York Museum.
„ deplexa, Phil.	•			•		—	r. C. R. of Ayton. Similar form occurs in the Dogger.
„ sp.			?			—	r. Smooth species in coils. York Museum.
Vermicularia compressa, Y. & B...	•	•				—	m. P. B. Scarborough Castle. Similar form occurs in the Dogger
Stylina tubulifera, Phil, ...				•		—	m. C. R., Grimston, Oswaldkirk, &c.

Genus—Species.	A.	I.	II.	III.	IV.	R.	*Localities and Remarks.*
Montlivaltia dispar, Phil.	—	—	—	*	—	—	c. C. R., Cawton, Oswaldkirk, Langton Wold.
Thecosmilia annularis, Flem.	—	*	—	*	—	—	v.c. L. C. R., Hackness. *Florigemma*-Rag generally.
Rhabdophyllia Phillipsi, Ed. & H.		*	*	*	—	→	v.c. L. C. R., Hackness; C. O., Pickering; C. R. generally.
Cladophyllia cæspitosa, Con. & Phil.	—	—	?	—	—	—	r. Base of C. O., Pickering. ?
Goniocora socialis, Rœm.	—	—	—	*	—	—	v.r. Single specimen, C. R., Langton Wold.
Isastræa explanata, Phil.	—	*	—	*	—	—	c. L. C. R., Hackness; C. R. generally.
Thamnastræa arachnoides, Park.	—	—	*	*	—	—	c. Base of C. O., Pickering; C. R. generally.
,, concinna, Goldf.	—	*		*	—	—	v.c. L. C. R., Hackness. C. R. generally.
Comoseris irradians, Ed. & H.	—	—	—	*	—	—	r. C. R., Langton Wold; Coneysthorpe.
Manon, ? foliaceum, M'Coy	—	*	—	—	—	—	l. L. L. Scarborough Castle.
"Sponge," silicified fragments	—	*	—	—	—	—	Passage-beds, Filey and Scarborough.
"Sponge," sp. sp., &c.	—	*	*	*	—	—	Forms due probably to sponges occur throughout.
Spongia floriceps, Phil.	—	*	—	—	—	—	l. L. C. R. Hackness, and throughout Scarborough district on that horizon.
Araucarites Hudlestoni, Carr.	—	—	*	—	—	—	v.r. Two cones from the C. O. of the Old Malton quarry.
Carpolithes conicus, L. & H.	—	*	*	—	—	—	c. Known chiefly from P. B., Appleton, and C. O., Malton.
Coniferus wood	—	*	*	?	—	—	Chiefly in the L. C. G.



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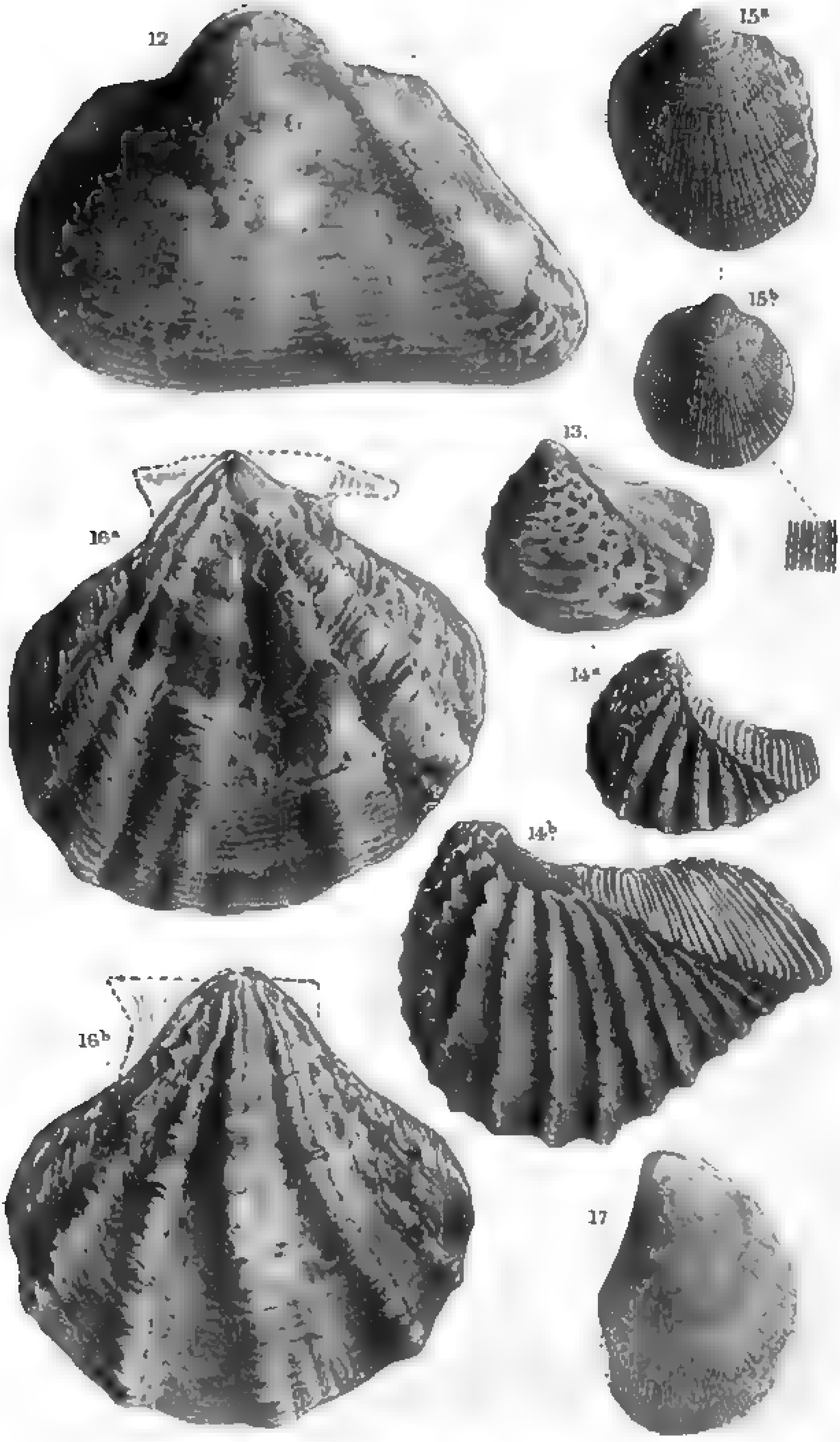

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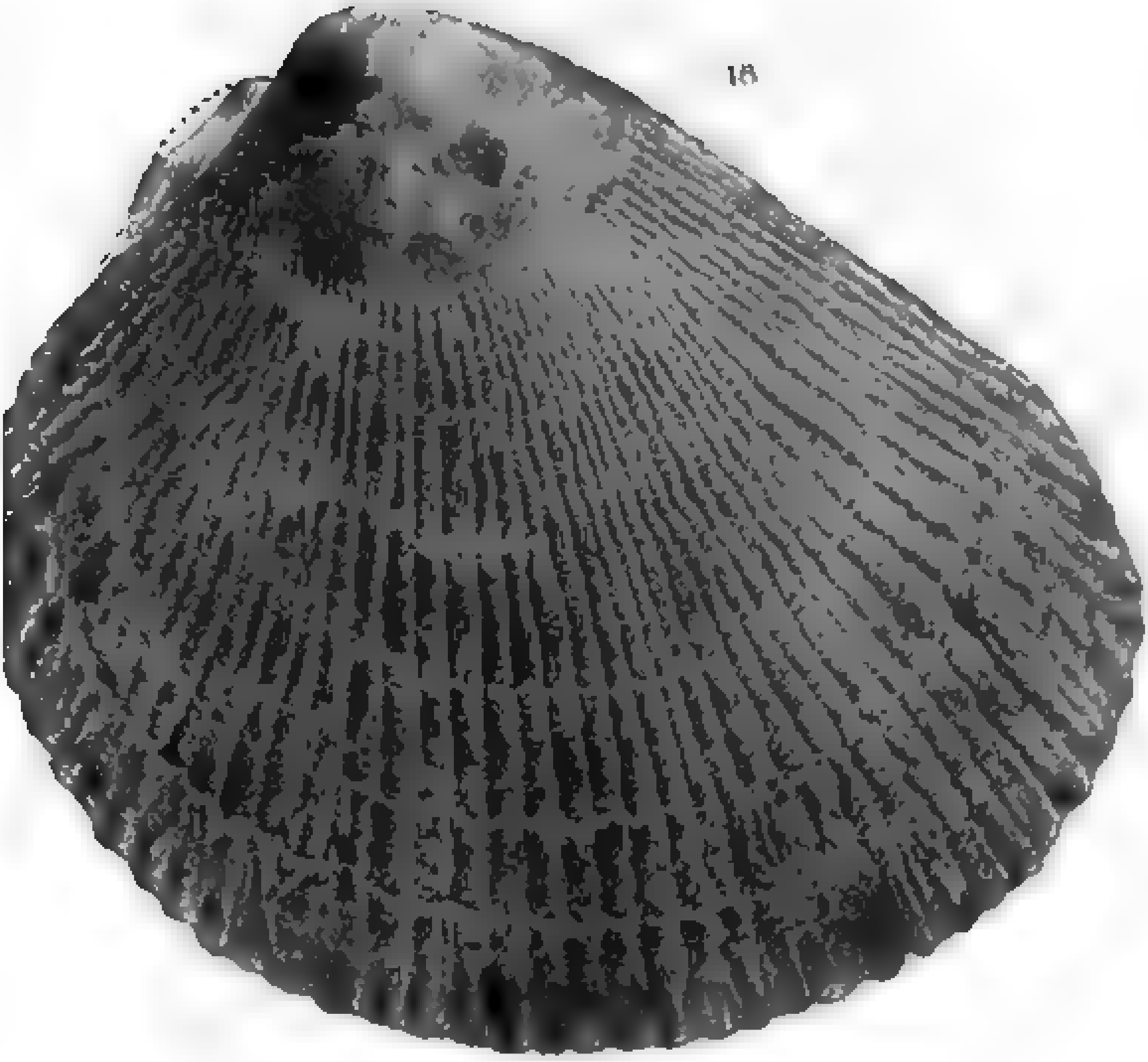

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EXCURSION TO THE NORTH DOWNS, SURREY.

MONDAY, 6TH MAY, 1878.

Directors—The PRESIDENT, Prof. MORRIS, F.G.S., and WILLIAM WHITAKER, Esq., B.A., F.G.S., Geological Survey.

(*Report by* W. WHITAKER.)

The party went by train to Caterham, and then walked southwards to the hill on which the Waterworks stand. The outlier of Oldhaven Beds here was examined, and it was shown how the wash of pebbles from this formation down the hill-side, or still more down the gentle northerly slope, obscured the junction with the Chalk, and might easily lead an observer to draw the boundary-line of the Oldhaven Beds too low.

Attention was drawn to the section given by the deep well at the Waterworks, the shaft of which passed through a great thickness of Oldhaven Beds (nearly 90 feet on one side, and 140 on the other); the Chalk was then pierced to the depth of about 455 feet; Upper Greensand, about 55 feet, succeeded, and then Gault, which reached the hitherto unrecorded thickness of over 340 feet; sand (Neocomian) being found below, and the total depth being 874 feet.

A large pit just south of the Waterworks showed the nature of the Oldhaven Beds—a deposit of flint pebbles in a sandy matrix, the pebbles all perfectly rolled; but in places, at the bottom, there was seen an irregular mass of angular flints in a loamy matrix; this, it was suggested, might be due to the dissolving away of the chalk by carbonated water, leaving the insoluble flints behind, which is all the more likely from the fact that the Oldhaven Beds must fill a deep pipe at the Waterworks (as shown by the well-section), and such pipes are produced by the dissolution of chalk below Tertiary and Drift beds.

An advance having been made to the edge of the Chalk-escarpment, Prof. Morris gave an address on the connection of the scenery of the district with the geology. Each successive formation (Chalk, Upper Greensand, Gault, Lower Greensand and Weald Clay), was shown to have its own peculiar effect on the surface, the contours of which moreover are greatly affected by the regular northerly dip of the beds.

The Chalk ridge having been descended, two trenches, dug at the foot of "White Hill," by Mr. Gilford, for the benefit of the Members, were examined. The more westerly and higher of these showed the junction of the Chalk and the Upper Greensand, or rather the passage between them; for the Chalk Marl was seen to be somewhat sandy at its base, and to put on the glauconitic character of the "Cambridge Greensand" (which has been shown to be the bottom bed of the Chalk Marl), until at last it passes into the clayey greensand that in this district forms the top division of the Upper Greensand. One of the party, well known as a worker in Cretaceous beds and fossils, was for a long time most distressingly sceptical as to the classification, on the ground that he couldn't find a certain Ammonite. At last, however, the desired fossil turned up, and all were happy! Nothing occurred afterwards to mar the blissful union of stratigraphy and palæontology.

The second trench showed a passage from the Upper Greensand into the Gault; the lower part of the former, consisting of more or less calcareous sandstone and sand, becoming more clayey towards the base, and merging into the top part of the Gault, which is sandy, somewhat calcareous, and light coloured.

The party was now in a fit state to discuss another kind attention of Mr. Gilford, in the shape of an open-air luncheon, laid out in a beautiful sheltered spot at the foot of the Chalk hill. Full justice having been done to the repast, and some complimentary remarks spoken, a start was made, by almost the whole, westward, along the terrace of the Upper Greensand.

Some small sections, showing the nature of the formation, the dip, &c., were noticed, and it was pointed out how the northerly dip, of about 5°, resulted in making the outcrop less winding, that is less affected by undulations of the ground, than would be the case with more horizontal beds. The lines dividing the Upper Greensand from the Chalk above and from the Gault below were approximately traced (on the "six-inch" Ordnance Map), and it was shown how this could be done from evidence given by the shape of the ground, the character of vegetation, and the occurrence of springs, in the absence of sections.

After a time the party came unexpectedly on a new and hitherto unrecorded section, which alone is worth a visit. It is a road-cutting on the west of Mr. Frith's new house, and is continuous from the base of the Chalk Marl to the top of the Gault. The

beds shown are as follows, and the section confirms the conclusions made at Mr. Gilford's trenches:—

CHALK MARL, full of green grains at the base, and passing down into the next bed.

UPPER GREENSAND.	Green sand, partly calcareous.
	Green and greenish-grey sand, with layers of sandstone; the stone more frequent lower down.
	Sand, partly calcareous, with layers of stone; lower down more clayey, and the stone-layers lost; passing down into the next.

Light-coloured sandy clay. Upper part of Gault.

It was felt by many of the geologists present that a prolonged stay should be made here, but this was hardly possible. Probably, however, an account of this section, and of others in the neighbourhood, will be communicated to the Geological Society next session, by the writer and his colleague Mr. Hawkins.

The walk was continued along the Upper Greensand, the outcrop of which was found to be rather narrower than is shown on the Geological Survey Map (made many years ago, and without the evidence above described). Before reaching Merstham a casual look was given to the large chalk-pit east of the railway, and then the party divided, some returning to London, others walking southward to Redhill, across the outcrop of the Gault to that of the Lower Greensand. The larger number then took train to London, but a band of six, resolved to have "a good ha'porth," continued their southerly stroll up the dip slope of the Lower Greensand to a fullers' earth pit close to the top of the escarpment of that formation, and were well rewarded by the sight of a fine section, the beds shown being as below, and all probably belonging to the Sandgate Beds of the Geological Survey:—

Brownish clay, in places with broken-up stone at top.

Sandstone, the upper part rubbly, and sometimes soft, the lower part more massive.

Fullers' earth, ironstained at top, the rest bluish-grey.

This pit, and some others in the same set of beds, will also be described in the communication above referred to.

EXCURSION TO TYLER'S HILL, CHESHAM.

SATURDAY, 18TH MAY, 1878.

Directors—JOHN EVANS, Esq, D.C.L., F.R.S., F.S.A., F.G.S, &c., and JOHN HOPKINSON, Esq., F.L.S, F.G.S., Hon. Sec. Watford Nat. Hist. Society.

(*Report by* MR. HOPKINSON.)

At various places beyond the northern limit of the London Tertiary Basin, outliers of the Lower Eocenes occur, ranging on the whole in a line parallel with the margin of the main mass of which they at one time formed a part. One of these, separated from the main mass by a greater distance than is usually the case, is at Tyler's Hill, or Cowcroft, as it is sometimes called, a mile and a half to the east of Chesham. The nearest railway station is at Boxmoor, and here, at about a quarter to three, a party consisting of Members of the Association and of the Watford Natural History Society, assembled for the purpose of visiting this outlier.

The distance being five miles each way, a waggonette was engaged, which the ladies of the party availed themselves of. An ascent by Box Lane had first to be made, and for about a mile up the hill the Chalk was seen to come to the surface, sections being exposed in several small pits, and in the road-side banks, owing to the road being excavated to reduce its steepness.

On the higher ground the Chalk is covered for a considerable distance with "brick-earth" and "clay with flints." This elevated plateau, some 500 feet above sea level, suddenly ends at Layhill Common, which is approached by a steep descent to the Chalk, here exposed by the erosion of a stream, no longer in existence, which at one time must have joined the Chess near Flaunden. From Layhill Common, where the Chalk is covered by Glacial gravel, there is a gentler rise of the ground towards the outlier, which is conspicuous for some distance by the dense wood which covers it. The presence of this wood seems to be entirely due to the existence of the outlier of which Tyler's Hill is formed; and to this outlier the protection of the hill itself from denudation is, no doubt, also due. A chalk-pit and brickfields expose a complete section of the hill from the London Clay down to the Chalk.

The following description of this section is given by Professor Prestwich, in his paper on "The Woolwich and Reading Series."*

		FEET.
London Clay.	Gravel, chiefly of flint-pebbles in clay, averages ...	4
	b. Brown clay with a few nodular septaria	10
	a. Layers of laminated grey and brown clay ...	3
Basement Bed of the London Clay, 3½ feet.	c. Layer of imperfect septaria, full of fossils† ...	0½
	b. Light brown sandy clay	2
	a. Flint-pebbles in clay	1
Woolwich and Reading Series, 31 feet.	h. Umber-coloured clay, in places slightly mottled red and yellow	2
	g. Fine siliceous sand, in places very white	3
	f. Light-coloured soft sandstone with an occasional pebble—variable	1
	e. Light-coloured siliceus sands with a few seams of grey clay, the lower part coarser, yellow, and brown	10
	d. Laminated grey and yellow clay and sand, with an under-seam of pebbles	1
	c. Yellow and ash-coloured sand with seams of grey clay	8
	b. grey clay laminated with sand	4
	a. Large unrolled flints, apparently white-coated ...	2
		51½
Chalk ...	... ...	25

Several sections exposed in the brickfields at various parts of the hill were examined; and at the Chalk-pit Mr. John Evans drew attention to the perfectly level surface of the Chalk, which seemed, he said, to be a surface of marine denudation.

After returning to Boxmoor, the Chalk-pit on Rough Down, chiefly known as being the place from which Mr. Evans has obtained most of the fossils of the Chalk-rock, was to have been visited, but tea proved a greater attraction, and there was not time to spare for both; so after only a distant view of the band of Chalk-rock, which here divides the Upper from the Lower Chalk, the party separated, most of the members of the two Societies leaving Boxmoor Station by the 7.37 train for Watford and London.

* Quart. Journ. Geol. Soc., Vol. x., p. 90.

† The *Ditrupa plana* abounds, together with *Ostrea Bellovacina*, a few *Natica glaucinoides*, a *Fusus*, and teeth of *Lamna*.

ORDINARY MEETING, June 7th, 1878.

Prof. Morris, F.G.S., President, in the Chair.

The following donations were announced :—

"Proceedings of the Liverpool Geological Society," Vol. iii., pt. 3 ; from that Society.

"Transactions of the Manchester Geological Society," Vol. xiv., pts. 18, 19 ; from that Society.

"Transactions of the Leicester Literary and Philosophical Society," Pt. 4, June, 1844, June, 1850 ; from that Society.

"Abstracts of the Proceedings of the Geological Society of London," Nos. 353-4 ; from that Society.

"Quarterly Journal of the Geological Society of London," No. 134 ; from that Society.

"Bulletin of the United States Geological Survey," Vol. iv., No. 2 ; from Dr. F. V. Hayden.

"Journal of the Society of Arts," Nos. 1329-32 ; from that Society.

The following were elected Members of the Association :—

Lestock Weatherby Cockburn, Esq. ; William Fawcett, Esq. ; Henry Fox, Esq., F.G.S. ; Thomas Radford Hope, Esq. ; Edward Provis, Esq., M.A. ; Winfred Rose, Esq. ; Lionel Varicas, Esq., C.E.

The following Papers were read :—

1. Notes on the Relations of the Igneous Rocks of Arthur's Seat.

By Prof. T. G. Bonney, M.A., F.R.S.

The Geology of Arthur's Seat has already engaged the attention of many authors, and received some notice in a communication recently printed in your Proceedings. It would therefore be presumptuous to hope to add largely to what is already known, but as I made one or two observations during a visit to Edinburgh last summer, which seemed to me to have some bearing on an important point of controversy, I venture to occupy part of your time this evening with a few remarks. The general structure of the hill is so well known that the briefest possible description will suffice to recall it to you. The summit is a conical peak, so steep as not to be readily accessible in every direction, which on the

south side descends rapidly to the lower ground near Duddingston Loch, and on the north side throws off three roughly parallel spurs. The first is capped by the grand escarpment of Salisbury Crags; the second, by a lower ridge called the Long Row; and the third forms a considerable mass named Whinny Hill.

The greater part of Arthur's Seat consists of volcanic products—lava flows and intrusive sheets, stratified ash and agglomerates; the remainder of shales and sandstones of Lower Carboniferous (Calciferous Sandstone) age. The summit cone is formed of a central knoll of basalt, enveloped by coarse agglomerates; on its flank is another conspicuous mass of basalt called the Lion's Haunch; important masses of the same rock occur at the base of the hill at each end and by the side of Duddingston Loch, and where the first spur inosculates with the cone is the well-known crag of columnar basalt, called Sampson's Ribs. Closely connected with this last is a sheet of intrusive basalt which diverges from the line of Salisbury Crag, and ultimately forms a low and almost parallel ridge, called St. Leonards Crag. Salisbury Crag, itself, is mainly formed by an intrusive sheet of dolerite. Behind it is the Hunter's Bog valley, on the opposite slope of which another intrusive sheet, termed the Dasses, is exposed, and above this rise the dark basalt crags of the Long Row. This is part of a flow; and above it we have a succession of ash-beds and lava flows, the upper group of which, seen on Whinny Hill, is not basalt, but porphyrite.

The structure of the hill has been the subject of much controversy, but at the present day we may regard only one important point as left open. This statement, I am aware, does not agree with some of the remarks printed in your Proceedings (Vol. v. p. 38-40), if I rightly understand the petrology of that paper—and I confess the author's meaning is not always clear to me. There can, however, be no question about the igneous origin of the "traps" of Arthur's Seat, and there is no evidence whatever of any special hydrothermal agency connected with them. The presence of the minerals mentioned by Mr. Taylor proves nothing, though no doubt such agency would be favourable to their production. They are common in most doleritic rocks of ancient date, and are due to ordinary causes, so that there is really nothing exceptional in the lithology of Arthur's Seat.

Accepting then, as beyond question, the igneous character of the crystalline rocks of Arthur's Seat—dolerites, basalts, and porphyrites—and attributing to such changes as they have undergone

in long lapse of time to the ordinary agents, there yet remains a controversial point on which I purpose to offer a few remarks. This is the age of the conical mass forming the upper part of the mountain. That this mass is closely connected with a volcanic vent is certain. The coarse agglomerates of which it is largely composed render this connexion obvious, but concerning its relation to the rest of the mountain, there are rival theories. One of these—originated, I believe, by Maclaren, and adopted by Professor Geikie—maintains that the hill consists of two wholly distinct series of outbursts, that the basalts of the Long Row, the tuffs and porphyrites of Whinny Hill, together with the intrusive dolerites of Salisbury Crag, the Dasses and St. Leonards Crag, belong to the earlier part of the Carboniferous Period, while the agglomerates forming the central hill, with their associated lavas, were ejected at a much later date, and after the older rocks had undergone great denudation. According to this view, the upper part of the hill is the stump of an old volcanic cone, and the basalt which forms the actual summit is a "plug" of lava that has hardened in its throat. The date of this later outburst is by some (as Professor Geikie) held to be Permian, by others (as the late Prof. E. Forbes) Miocene.

The other view was advocated by Professor Judd, in an exhaustive paper published in the Quart. Journ. Geol. Soc., Vol. xxxi, p. 131. He considers that the igneous rocks of Arthur's Seat are the result of one series of phenomena only, the upper part of the hill representing the "neck" of the volcanic orifice, from which, in successive eruptions during the earlier part of the Carboniferous epoch, were ejected the lava flows and ashes of the Long Row and Whinny Hill, and the intrusive sheets and dykes in the underlying strata. The reasons which have led this distinguished geologist to the above conclusions are thus summed up by himself:—

(1). The antecedent improbabilities of the theory of two great periods of eruption for the rocks of Arthur's Seat are exceedingly great, if not altogether improbable.

(2). The supposed proofs of a second period of eruption break down upon re-examination.

With regard to the former objection, I have always felt that the antecedent improbability was not so very great.* Professor Judd himself has told us of remarkable instances of repeated volcanic

* It may be well to remark that I see no reason for supposing that the orifice of the Carboniferous volcano at all corresponded with the existing cone. Of the former I can see no trace, and it may have been some distance away.

disturbances in the Western Isles of Scotland. Cones comparatively modern have broken forth on the flanks of the old trachyte massifs, and through the great basalt sheets of Miocene age in Auvergne, and I have myself described instances in Cornwall, Ayrshire, and Charnwood, where intrusive igneous rocks most probably succeeded one another after long intervals. At the same time it is no doubt true, as the author stated in the discussion after his paper, that the *onus probandi* is with those who adopt this theory. I shall accordingly lay before you this evening some evidence as to the relation of the cone to the rest of the hill, which I think, if my view can be established, is conclusive, together with the results of some studies of the component rocks, which have an indirect bearing on the controversy. With regard, then, to the structure of the hill itself. It is usual to represent the fine columnar mass of basalt, popularly known as Sampson's Ribs, as a sort of ganglion, whence proceed the two sheets forming Salisbury Crag and St. Leonards Crag. I think this identity very doubtful for the following reasons. The great mass of intrusive dolerite in Salisbury Crag cannot be traced to the upper part of Sampson's Ribs, but is separated from the latter by a considerable interval. The St. Leonards Crag sheet can be followed along the green slope beneath the Queen's Drive to within about 40 yards of Sampson's Ribs; between these two rocks, however, there are noteworthy differences. The former makes a kind of ledge just interrupting the turf slope, as though it were of little thickness and gradually thinning out. The latter is a great columnar mass with a totally different aspect. The texture also of the two rocks is very dissimilar; the St. Leonards Crag rock is here rather amygdaloidal, and not porphyritic, a somewhat decomposed finely crystalline anamesite or basalt—that of Sampson's Ribs is not amygdaloidal, has a compact ground-mass, but is porphyritic, the crystals of plagioclase being commonly about $\frac{1}{4}''$ long, and it retains this character almost to the very outside. The dissimilarity of the two rocks, I think, cannot fail to strike any one who examines them on the ground. Again the dolerite of Salisbury Crag is obviously very unlike the basalt of Sampson's Ribs, being more closely related to that of St. Leonards Crag; as however the two rocks are separated by a considerable interval we cannot lay too much stress on this dissimilarity, although we may fairly attribute to it some weight.

When we ascend to the Queen's Drive we shall find other difficulties in the proposed identification. This road cuts through

the upper part of the basalt of Sampson's Ribs, though the section is now obscured by masonry. At the east end a knoll of columnar basalt interrupts the turf a few feet above the road. This is clearly a part of the same mass as Sampson's Ribs. It seems to show that this basalt is either interstratified with or intrusive in a coarse red agglomerate.

Returning westwards through the cutting, we come to some basalt on the north side of the road, which seems to me to have an important bearing on the controversy. I think there can be no doubt it is continuous with, at least, the upper part of the Sampson's Ribs mass, and it is overlain by a peculiar red-coloured agglomerate already mentioned, which is a marked feature on this side of the hill. The under side of this basalt, which is visible immediately above the road, overlying an indurated agglomerate, full of scoria and porphyrite fragments, has a most remarkable resemblance to the base of a true flow. Cavities occur in it for about 5 inches from the exterior, the parts between having that peculiar slaggy aspect so characteristic of the exterior of a flow; then the rock for a short space is irregularly jointed, and lastly becomes more regular. It has a porphyritic structure like that of Sampson's Ribs, and this structure continues, though less distinct, even into the slaggy part. I spent much time in tracing the upper surface of this basalt, with a view of ascertaining what alteration, if any, it had produced on the base of the overlying agglomerate. On this point I cannot say that I obtained decisive evidence. Here difficulties in climbing opposed; there the basalt was masked by fragments from above; or its surface was so decomposed as to be almost indistinguishable from the matrix of the agglomerate. But certainly I saw no evidence of intrusion—none of local induration of the base of the agglomerate; and here also, so far as I could form an opinion, it looks more like a flow. I traced this basalt up the hill till I followed it to a kind of corrie below, and not far from the summit, where the cliffs arrested my progress. I could not succeed in following with my eye its outcrop along them, so perhaps it is here concealed beneath agglomerate.

If, then, the basalt of Sampson's Ribs be intrusive, there must be a great dyke connected with it, forming a third sheet or spur radiating from that knot point: but if, as I think is far more probable, the above basalt is a flow—of which Sampson's Ribs is also a part—then, as a glance at the diagram shows, it cuts right across the strike of the sedimentary beds, into which the Salisbury Crag and

St. Leonards Crag dolerites are intruded, and so must rest upon their denuded edges.

FIG. 1. DIAGRAMMATIC SKETCH OF ARTHUR'S SEAT.—FROM THE SIDE OF SALISBURY CRAG.

A—End of Salisbury Crag Sheet. B—End of St. Leonards Crag Sheet. C—Continuous with Sampson's Ribs. D—Calciferous Sandstones. E—Queen's Drive.

N.B.—The position of the boundary of the basalt and agglomerate in the greater part of the hill is more or less conjectural.

The mass of basalt which forms Sampson's Ribs is, no doubt, thicker than the mass which I have been describing; but this is not a serious difficulty in the hypothesis of a flow, as such a shape would not improbably be assumed by a viscid mass, trickling, as it were, down the cone, even supposing that the flatter land at its base were not reached just about that point.*

Another point may here be mentioned. The pseudostratification of the basalt forming the summit of Arthur's Seat, to which attention has been called by Prof. Judd, is undoubted. To one standing on the Queen's Drive, and looking towards the part of which I have been speaking, the layers seem to dip gently to the left; but the red agglomerate shows a no less distinct bedding or parallel jointing† in planes roughly parallel to the basalt which we have been tracing, and so dipping to the right.

A difficulty in the fissure theory is also raised by some further evidence of stratification in the materials of the cone. The steep slopes of the hill, in some parts covered with grass, in others troublesome, if not dangerous, to climb, makes the investigation of this no easy task; but the Queen's Drive affords a fair section of the cone, though this is not what it must have been before the retaining walls were built. I examined it carefully for a distance of about 430 paces, commencing with a basalt on the east side, up to the outcropping mass connected with that of Sampson's Ribs on the west end.

This eastern basalt,‡ first shown by the side of the road from Duddingston to Edinburgh, can be followed up the hill-side to the upper road, forming a bold scarp; crossing this, it can be traced some distance up towards the summit§. The basalt is amygda-

* The arrangements of the columns in Sampson's Ribs (though we must not rely too much on this) seems to accord better with the idea of a flow than an intrusive mass.

† I have measured the angle in each case in a fairly careful drawing (as well as in some rougher sketches). I find the dip in the latter case about 20°, in the former two or three degrees less. Hence the two planes form an obtuse angle of about 142°. Thus, if the plane in the basalt be placed horizontal, a dip of about 38° is given to that of the agglomerate, which seems far more probable in a cone than in a fissure.

‡ Supposed by the Scotch Survey identical with the Long Row basalt.

§ This, I believe, is the critical section noticed by Prof. Judd, Quar. Journ. Geol. Soc., Vol. xxxi., p. 139. On this point I have no fresh remarks to offer. The disappearance of the basalt might be caused either by a fissure or overlap of the agglomerate. I must admit that it seemed rather to overlie the agglomerate, but this appearance might be deceptive, owing to slipping of the materials from above. Just here the hill-side is steep, and investigation not always easy.

loidal, the amygdaloids being sometimes as much as two inches long, and certainly seems to resemble a flow.

A wall masks the section for about 83 paces, and then we see a small quantity of fine agglomerate (matrix soft, blocks up to 6" diam.) underlying another agglomerate which has blocks double the size, and is so much indurated as to be distinctly jointed; the dip of the junction surface is opposite to the apparent dip of the beds in the hill. This is intelligible as a result of false bedding in a cone, but rather difficult to explain in a fissure.

A little further on the agglomerate becomes softer; then, after passing a small knob of rock, of dubious origin, we find a very coarse agglomerate with a soft matrix. We then come to some curious marly bands underlying the coarse agglomerate, with a basalt dyke on the left. This section, puzzling in any case, is, I think, more easily explained on the cone theory than any other. Beyond this basalt comes another agglomerate, apparently underlying it, and we then arrive at a basalt dyke, about a yard wide, part of which is in good condition. It is an olivine basalt, much like that of the Lion's Haunch.

To this succeeds a grey agglomerate; and then, overlying it, the red agglomerate already mentioned, in which also we see a portion of an intrusive dyke or a *coulée*. I cannot say that the evidence from this section is conclusive; but the general impression which it produced on my mind was that it accorded better with the theory of a cone of ejection, than a neck or filled-up fissure.

In the hope of obtaining additional evidence I have examined, microscopically, the structure of the basalt of Sampson's Ribs, which certainly appears to me to support the view which I have put forward. I had a slide cut from a fairly typical and well-preserved specimen. It exhibits a vast number of crystals of plagioclase felspar, averaging about ·007 inch long, together with magnetite, and augite microliths. Of these the ground mass is chiefly composed, but there seem occasional traces of an uncrystallized magma. Here and there a fair amount of a substance is visible, which with crossed nicols, exhibits an ill-defined micro-crystalline structure, changing from milky white to dark, and resembling an appearance not rare in some devitrified glassy rocks. Perhaps this may be its character here, or it may be a decomposition product from the plagioclase microliths, as it is not unlike parts of so-called saussurite. Here and there minute colourless acicular microliths are visible, which I am disposed to regard as zeolitic minerals and not apatite.

The ground-mass shows some indications of a fluidal structure. Larger plagioclase crystals are present, exhibiting the characteristic stripings, and containing many enclosures of the ground mass, and magnetite, and (?) augite. There are also larger grains of magnetite, augite, and olivine, the last mainly converted into serpentinous pseudomorphs, part of which are dichroic and show bright colours with crossing nicols.

The rock of Salisbury Crag has been fully described by Mr. Allport,* so that I need say no more than that it is microscopically as different from that of Sampson's Ribs, as it is macroscopically. Doubtless, it is not safe to place too much reliance upon similarity or dissimilarity of igneous rocks as a test of age, but I must say that the dissimilarity between these three rocks—St. Leonards Crag, Salisbury Crag, and Sampson's Ribs—is so great, that it is most difficult to suppose them parts of one and the same intrusive mass. We may also be surprised at finding the greatest resemblance to a flow structure in the last, when on the intrusion theory it must have cooled at a rather greater depth, and in a thicker mass than that of Salisbury Crag.

With regard to the identity of the other rocks, I have made a few observations. It was suggested by the late Mr. Maclaren, that the basalt of the Lion's Haunch, might be identical with that by the loch side, under Duddingston Church.† This I think is hardly possible. The habit of the two rocks is totally different: the former (though nearer to the source) contains larger grains of augite and olivine, which are very conspicuous in it. It appears also to be a rather blacker and heavier rock, and has a peculiar mode of weathering, forming a brown surface layer, in which the black augite crystals are very conspicuous. I saw no sign of this habit in the Duddingston rock. The microscopic structures also differ considerably, as the following account will show—

The Lion's Haunch basalt has a glassy base, crowded with minute microliths of felspar, augite, and magnetite, in which are scattered numerous crystals of plagioclase (generally labradorite, but some of the smaller much resemble orthoclase) crystals of augite, grains of

* Mr. Allport's collection is now in the British Museum, and I am indebted to the courtesy of Prof. Maskelyne and Mr. T. Davies for the opportunity of studying the slides.

† I find it very hard also to understand how, if the Duddingston basalt is identical with that east of St. Antony's Chapel, it could be connected with the mass of the Lion's Haunch, though I quite agree with Prof. Judd in supposing the last to be mainly a coulée.

DIAGRAMMATIC SECTIONS THROUGH ARTHUR'S SEAT.—ILLUSTRATING THE TWO THEORIES OF THE MODE OF ITS FORMATION.

(From Vol. XXXI. of the Quarterly Journal of the Geological Society, by permission of the Council of the Society.)

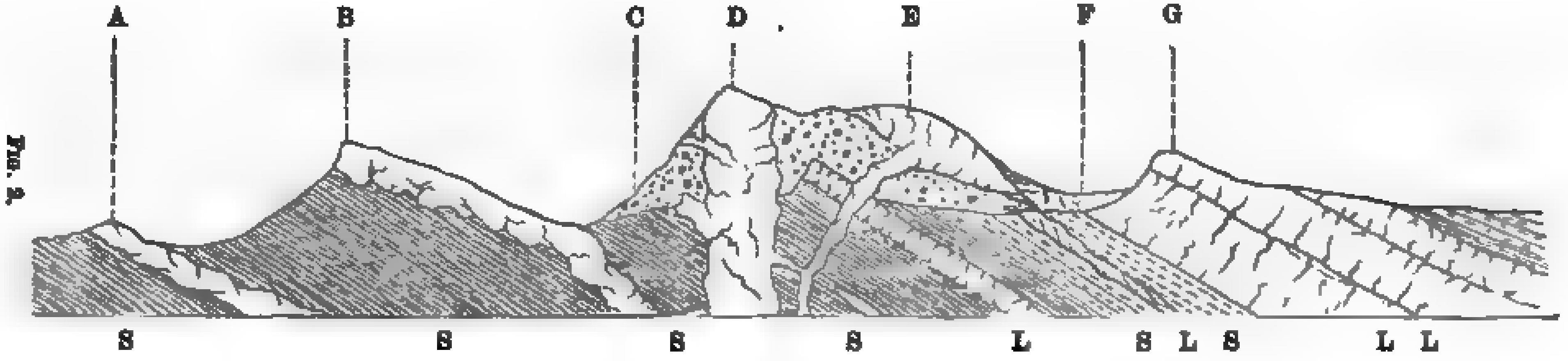

FIG. 2.
Two distinct periods of eruption.

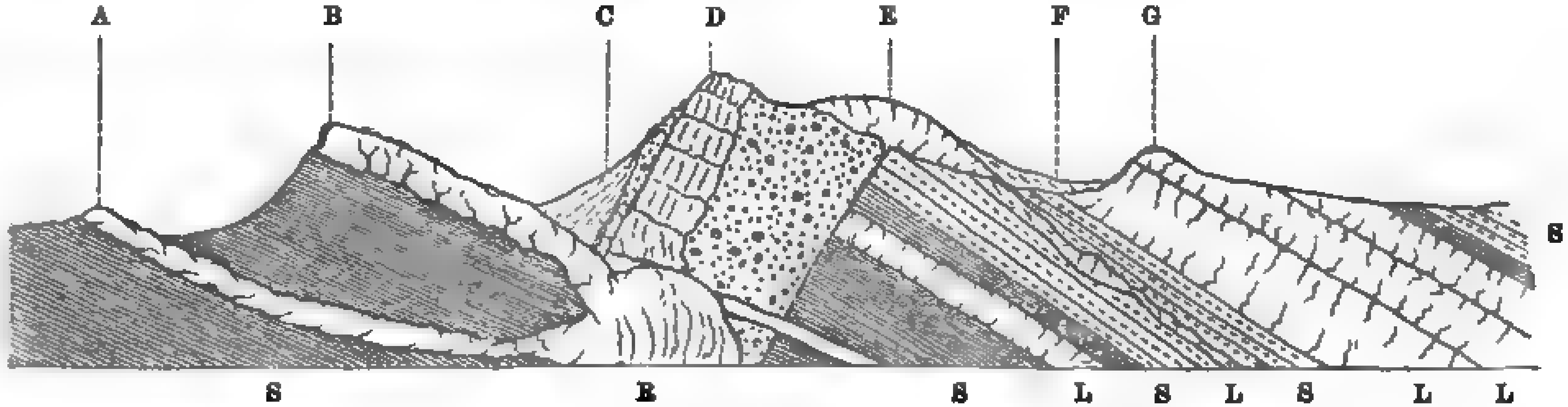

FIG. 3.
One period of eruption.

A.—St. Leonard's Crags. B.—Salisbury Crags. C.—Coarse Agglomerates. D.—Apex of Arthur's Seat (basalt). E.—The Lion's Haunch. F.—Lava Stream of Porphyrite. G.—Part of Winny Hill. L.—Lava Flows. S.—Sandstone Shales R.—Sampson's Ribs.

[From Prof. Judd's Paper, Quart. Journ. Geol. Soc., Vol. XXXI., p. 144. *By kind permission.*

magnetite, and a good many of olivine, the last being more or less completely converted into a rather fibrous, clear, pale green mineral, slightly dichroic and exhibiting with both nicols some fairly bright coloured fibres. The larger felspar crystals frequently contain numerous microliths both of magnetite and of augite, exhibiting sometimes a zonal arrangement. The basalt under Duddingston Church is somewhat similar in general structure, but the presence of a base is doubtful. The microliths in the plagioclase are rarer and less distinctly zonal. The magnetite occurs in larger grains, and appears to be less abundant; the former rock being richer in it than almost any basalt which I have seen. A part of the slide exhibits traces of the curious arrangement of acicular ferruginous microliths figured by Boricky.* But while I cannot admit of the identification of these two rocks, and prefer that suggested by the Survey, I may remind you of the small dyke of basalt by the Queen's Drive, about 150 yards from the west end of the Sampson's Ribs massif, which has a very close resemblance indeed to the Lion's Haunch, allowing for the difference of the circumstances.

It is possible that the Girnal Crag massif may be identical with that forming the Dasses on the north side of the mountain, but I cannot say that the resemblance, macroscopic or microscopic, impressed me so much as it appears to have done the Scotch surveyors, and of course identification of intrusive rocks at places full $\frac{1}{8}$ mile a part, must be conjectural. Still if the basalt sheet above it which has been already described, represents that of the Long Row (an indentification very probable), this other basalt, which I think certainly intrusive, is about in the position of the Dasses. I may add that its microscopic structure is suggestive rather of the Salisbury Crag type than of the others which I have mentioned. It is wholly crystalline, consisting of plagioclase felspar, brown augite, hematite or ilmenite, and olivine, partly altered into a serpentinous mineral; a good deal of the felspar is traversed by minute cracks, lined with infiltrative products; microliths are frequent in the augite, and there are rather numerous hexagonal needles in the slide, probably of apatite.† It disappears from the hill side a little below the Queen's Drive, and is not seen in the section on the other side of the road, unless it be represented by a small knob of igneous rock just visible here, which, however, is very doubtful.

* Petrogr. Studien an den Basalt. Bohm., pl. I.

† This mineral is also common in the Salisbury and St. Leonards Crag rocks, but less common, so far as I have ascertained, in that of Sampson's Ribs and in the acknowledged flows.

To sum up. The following is the result of the considerations which I have laid before you. The evidence of the cone itself and its structure is not decisive; still I confess to thinking its structure seems more easily explained by regarding it as a ruined cone rather than a volcanic neck.

(2) Whatever be the nature of the mass of rock at Sampson's Ribs, it is probably disconnected from that of St. Leonards Crag and Salisbury Crag.

(3) There is some reason to think that this basalt of Sampson's Ribs is not intrusive in the agglomerate, but is a true flow interbedded in it. If this be the case, the cone must be of later date than the rest of the hill, for not only (according to Maclaren) do the calciferous shales pass under the base of this basalt massif, but it cuts across the strike of the sedimentary beds in Salisbury Crag. I do not indeed consider that the evidence on this critical point is decisive; perhaps such evidence can never be obtained; but I think I may venture to assert that had nothing depended on the question whether this basalt were a dyke or a flow, I should have asserted without hesitation that the latter was the more probable.

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2. On Microscopic Rock Sections.

By J. Slade, Esq., F.G.S.

VISIT TO THE GARDENS OF THE ZOOLOGICAL SOCIETY.

June 5th, 1878.

Director—Dr. P. L. Sclater, M.A., F.R.S., Secretary to the Society.

(*Report by* Henry Walker, Esq., F.G.S.)

At the invitation of Dr. Sclater, the Members assembled at the principal entrance to the Gardens, where they were admitted free, and presented with the new edition of the Guide to the Gardens.

The first visit was paid to the Bears' Den. By the aid of a map the Director pointed out the geographical distribution of the family Ursidæ in Europe, Asia, North and South America, and South Africa, and their absence from the great Australian region. The

Gardens of the Society are well supplied with specimens of the Brown Bear, *Ursus Arctos*, whose remote progenitor was the Cave Bear, remains of which are found in the gravels of the Thames. The Director cautioned his hearers against the notion that the frugivorous or carnivorous habits of ursine species can be inferred from the character of the teeth or skull. The Polar Bear (*Ursus maritimus*), is carnivorous, but the Sloth Boar (*Melursus labiatus*), does not eat flesh under any circumstances, yet it would be impossible to distinguish between the teeth of the two species. The Seal Pond was then visited for examples of the Marine Carnivora. At present there are no seals or walruses in the Gardens, but the family *Otariidæ* are represented by the Patagonian Sea Lion (*Otaria jubata*), discovered only some ten or twelve years since. The male is enormously larger than the female, and at certain times of the year has a mane. The Director remarked that fossil remains of the Seal and Walrus have recently been found in the Tertiaries of Antwerp; previously they were not common in geological formations.

The party then proceeded to the New Lion-house, to inspect the chief family of the Terrestrial Carnivora. Notwithstanding the ample donations which are constantly being made to this collection the Ounce or Leopard of North Asia has never been shown alive in the Gardens. The geographical range of the Tiger, and the fact that it exists in parts of North-eastern Asia where there are six months' frost, were dwelt upon by the Director, in correction of the notion that the species is confined to hot climates. Another mistake was to assume that all the larger quadrupeds of the world had already been discovered. The audience had before them, in the cage opposite, a new and large species of Cheetah which was utterly unknown so recently as two years ago. This specimen (the Woolly Cheetah) comes from South Africa. The Kangaroo sheds were then visited, and the characteristics and geographical range of the Marsupials were described. In the Elephant-house, to which the party subsequently proceeded, the Conductor observed that the North African species is still abundant on the east side of the Continent, but scarce in Cape Colony. The belief that *Elephas Africanus* is not tameable had been sufficiently contradicted by experience in the Zoological Gardens, where it was found to be as docile as the Indian species. The Rhinoceroses and the Tapirs next came under review, and the geological interest of the latter to the dwellers in the London Clay was pointed out. Of this old group, three

species were found living to-day in America, and one in India. The Andes of South America contain a distinct species, living some eight or ten thousand feet above the sea. The Director then gave an interesting account of the dentition of the Hippopotamus, beginning with the remarkable series of species—numbering from twelve to twenty—which are found in a fossil state in the Siwalik Hills. At the conclusion of the visit, the cordial thanks of the Association were presented to Dr. Sclater through Professor Morris and Professor Tennant.

EXCURSION TO NORWICH AND CROMER.

JUNE 10TH (WHIT-MONDAY) AND FOLLOWING DAY.

Directors.—F. W. HARMER, ESQ., F.G.S., HORACE B. WOODWARD, ESQ., F.G.S., AND CLEMENT REID, ESQ., F.G.S.

(*Report by* H. B. WOODWARD, ESQ., and C. REID, ESQ.)

Leaving London by the 9.10 a.m. train from Liverpool Street, the Members of the Association arrived at Trowse station about one o'clock, and were there joined by the Directors and by several Members of the Norwich Geological and Naturalists' Societies.

They at once proceeded through the village of Trowse to the chalk-pit on the Crown Point Estate. Here the Chalk itself, with conspicuous layers of flint, was seen to be tilted up at a considerable angle, and it was overlaid by beds belonging to the Norwich Crag similarly disturbed. Mr. Woodward pointed out that this was due to glacial agency, for along one face of the pit the entire mass of what appeared to be chalk was re-arranged and mixed up with clay and sand, while it contained not only broken flints, but pebbles of flint, quartz, and quartzite. This re-constructed chalk had assumed a rude stratification, and partly underlaid the solid chalk where it was most highly tilted.

Mr. Woodward briefly called attention to some of the common fossils of the Chalk, exhibiting specimens of the *Terebratula carnea* and *Rhynchonella plicatilis*. The paramoudras formed prominent features in this pit; some were seen *in situ*, and it was observed that they were now more abundant here than at the famous pit at Horstead, figured by Lyell.*

Concerning their mode of origin, it was stated that their forms

* Quart Journ. Geol. Soc., Vol. xxxiii., p. 82.

were inorganic, for in shape they passed by gradation into flints of most irregular outline, and often enclosed organisms whose structure was originally calcareous. Possibly the flint collected round some sponge as a nucleus, whose subsequent decay gave rise to the central cavity which characterizes the paramoudra.

Referring to the Norwich Crag, Mr. Woodward pointed out that it comprised beds of laminated clay, sand, and shingle, with here and there patches of shells. He had noticed two seams of shells at Trowse. Possibly some of the top beds of sand might belong to the Glacial period, for when the sandy and gravelly beds of this age rested directly upon the Norwich Crag, it was often difficult to draw a line of demarcation.

Mr. Harmer observed that the Chalk exposed on the sides of the valleys of the Yare and Wensum frequently showed signs of glaciation, and, in conjunction with Mr. Searles Wood, jun., he had been led to the conclusion that the valleys had been excavated to a considerable extent subsequently to the deposition of the Contorted Drift, and prior to that of the Middle Glacial Sand and Chalky Boulder Clay.

Leaving Trowse pit, the party proceeded through the park (now the property of J. J. Colman, Esq., M.P.) to the pits near Whitlingham Church. Here the Norwich Crag was again seen overlying the Chalk, and its exceedingly variable nature was pointed out by Mr. Woodward in the larger pit, where shells were visible, and where he had noticed three horizons in patches on one face of the pit, while on the opposite side shells were absent. He also drew attention to the occurrence in the Crag-series of ironstone nodules, consisting of a hard shell of iron sandstone with a nucleus of clay iron-ore or ochre, and he expressed the opinion that these nodules originated from the segregation of iron oxide around clay pebbles, which are often present in the series, and from which gradations in structure might be traced.

One or two instances of paramoudras occurring in a vertical line were noticed, and Mr. Harmer remarked upon the former presence of a very striking "saddle" or anticlinal disturbance in the Chalk, to which attention was drawn, in 1868, by Mr. J. E. Taylor, when the Members of the British Association made an excursion to the pit, but which had since then almost entirely been worked away.*

With the aid of the map prepared by Mr. Wood, jun., and him-

* See fig. 21, in Woodward's "Geology of England and Wales," p. 287.

self, and published in the "Supplement to the Crag Mollusca" (1872), Mr. Harmer pointed out the general relations of the Norwich Crag to the Red and Coralline Crags of Suffolk, and dwelt at some length upon the physical conditions of the area during their deposition.

A halt was made on the river-bank, where flints are dressed for building purposes, and much interest was shown in the mode of flaking, as performed by one of the knappers who practically illustrated the subject. It was mentioned that gun-flints were still manufactured at Brandon for export to South Africa, and Mr. Woodward exhibited some specimens from that locality.

Most of the Members then proceeded in a boat to Postwick Grove, the remainder walking along the river bank to be ferried across when they reached the opposite point. Postwick Grove pit was then inspected, and the Norwich Crag was seen in places, but the pit not having been worked for many years, the structure of the beds was not displayed. *Tellina obliqua*, *T. prætenuis*, *Mactra ovalis*, *Trophon antiquus*, *Purpura lapillus*, *Litorina litorea*, and other common fossils were obtained.

Further on, by Thorpe Asylum, a pit in a Chalky Boulder Clay, which occurred low down on the borders of the Alluvium was pointed out by Mr. Harmer. This he considered to be connected with the excavation of the valley during interglacial times.*

After a short stay at the "Griffin," the party proceeded to the Thorpe Lime-kiln, and the Norwich Crag was found to be very well exposed, and numerous shells were obtained. The stone-bed, which consisted of a bed of flint boulders one to two feet in thickness, was pointed out here, as well as at Whitlingham, and in this bed most of the mammalian remains had been obtained.

Mr. Fitch had in his possession bones and teeth of *Mastodon*, *Elephas meridionalis*, Bear, Horse, Ox, Leopard, Hyæna, and *Trogontherium* from this bed. Mr. Harmer observed in reference especially to the Mastodon, that it no more belonged to the period of the Norwich Crag than did the flints among which it occurred, and he maintained that it was derived from some earlier deposit in which the remains of the Mastodon had been entombed.† Mr. Woodward drew attention to a hard bed in the

* See Paper, by Wood and Harmer, Quart. Journ. Geol. Soc., Vol. xxxiii., p. 84.

† See paper by Harmer, Quart. Journ. Geol. Soc., Vol. xxxiii, p. 138.

Crag Series, which had been cemented by iron-oxide, and exhibited some casts of shells, including *Mytilus*, *Tellina*, and *Nucula*, which were to be found at the eastern extremity of the pit.

Proceeding along the lane towards the Plumstead Road, the Lower Glacial beds consisting of brick-earth and sand, which overlaid the Norwich Crag, were well seen, and were characterized by the contortions which have led to the application of the term Contorted Drift.

After a walk of about three miles the party proceeded to examine the coarse gravel so well shown in Mr. Moore's pit on Mousehold. This gravel is known as the "cannon-shot" gravel, from the huge boulders of flint of which it is mainly composed. Some igneous rocks and boulders of quartz and quartzite were also observed. In the flints are many casts of echinoderms, and some sponges, which are said not to occur in the highest members of the Chalk exposed at Norwich. Most of the flint-boulders exhibited signs of having been much battered about, and, as was pointed out by Mr. Harmer, they were evidently deposited somewhat rapidly and tumultuously, for the longer axes of the boulders were not unfrequently vertical. It has been suggested that the gravel was formed during seasons of flood, possibly due to the melting of an ice-sheet—an opinion supported by Mr. Skertchly, who together with Dr. James Geikie, has advocated the land-origin of the Chalky Boulder Clay.

Passing to the precincts of Kett's Castle, the party entered the grounds of J. B. Ladbrooke, Esq., who kindly gave the Members permission to take a peep of the grand view over the Wensum Valley and across Norwich, which is to be gained from the terrace adjoining his house.

Descending the hill to Bishop's Bridge, a visit was next paid to the large chalk-pit near Thorpe Hamlet Church. Here there were seen in one face in succession all the beds from the Chalk upwards to the coarse gravels, which, with the exception of the Chalky Boulder Clay, had been previously examined in the course of the day. The Chalk itself had yielded some of the finest remains of the *Mosasaurus* obtained near Norwich. Above it rested beds of sand and gravel with seams of laminated clay classed with the Norwich Crag. Here some difference of opinion was expressed by Mr. Harmer and Mr. Woodward, the former regarding certain seams of laminated clay as marking the junction between the

Norwich Crag and Lower Glacial series, while the latter included all the beds up to the base of the brick-earth as Norwich Crag. Mr. Harmer pointed out that this brick-earth, which belonged to the Contorted Drift, was extensively worked around Norwich for the manufacture of bricks and tiles.

Leaving this pit the party proceeded to the Maid's Head Hotel, where most of the Members remained for the night.

On the following day, the Members started by the 9.2 a.m. train to Cromer, where conveyances awaited to take them to Sherringham. The route lay along one of the most picturesque parts of Norfolk, and the drive through the grounds of H. R. Upcher, Esq., commanded most beautiful views.

After a brief halt at the "Lobster," at Sherringham, the party proceeded along the beach towards Cromer. Attention was at once given to the remarkable contortions exhibited in the brick-earths and sands of the Contorted Drift, while the huge transported masses of Chalk-with-flints excited considerable interest and discussion. One of these masses extended for a length of about 300 yards. Mr. Harmer explained that the contortions were due to the agency which introduced the masses of chalk, and these masses he considered could only have been borne by icebergs of considerable size. He also pointed out that the sands and gravels, termed Middle Glacial, occupied troughs in the Contorted Drift, and these he regarded as due to interglacial denudation when other valleys in Norfolk were likewise eroded.

Mr. Reid was of opinion that the masses of chalk had been pushed along and not lifted, in many cases having been thrust into the yielding materials after their deposition, and pointed out that they usually appear to have contorted the *overlying* beds, which would not be the case if these beds were of later date. He also observed that the sands and gravels generally identified with the Middle Glacial of Yarmouth are nearly always affected by the contortions in the Contorted Drift.

At West Runton attention was drawn to the succession of the Pre-Glacial Beds.

The Myalis-bed, described by Mr. Reid,* was not well-exposed, owing to the talus that obscured the cliffs; but its position was pointed out, and a few decayed specimens of *Mya truncata* were found.

* "Geological Magazine," Dec. II., Vol. iv, p. 300.

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* "Geological Magazine," Dec. II., Vol. iv, p. 300.

Beneath, came the Black freshwater-bed, which was so conspicuous a feature near the base of the cliffs. Many freshwater Mollusca, such as *Unio*, *Paludina*, &c., were obtained.

Besides these, the bed has yielded bones of *Castor*, *Trogontherium*, *Sorex*, *Arvicola*, Fishes, Insects, and Seeds.

Mr. Reid drew attention to the weathered appearance of the clays immediately underlying the freshwater bed, and on digging into them several small roots were seen. These roots were not sufficiently well preserved for microscopic examination, but they had the appearance of Yew or Fir. This soil or "Rootlet Bed," he regarded as the weathered upper part of the estuarine Weybourne Beds, which consist of a very variable series of blue clays, sands, and gravel, the last-mentioned occasionally cemented by iron-oxide into a hard conglomerate or "pan." The fossils are equally varied, for at Runton a single bed contained numerous bones of elephant, with cockles, land-snails, and wood ; while at other localities these materials are at different horizons. The masses of lignite form the well known "Forest Bed," and often contain the stools of trees, some imbedded in an upright position, others upside down and at various angles. The Forest Bed has its principal development east of Cromer, but the state of the tide did not admit of these lower beds being examined. Mr. Reid remarked that, speaking generally, the lower part of the Weybourne Beds was marine, and the upper part estuarine, or in places fluviatile. *Tellina Balthica*, a shell as yet unknown in the lowest stages of the Norwich Crag, is abundant in marine beds throughout, and derivative fragments of it are not uncommon in the overlying Freshwater Bed of Runton.

It was mentioned that a Palæolithic Implement had been found by Mr. A. C. Savin in the valley-gravel that caps the cliffs at Runton.

The proceedings terminated by a dinner at Tucker's Hotel, Cromer, after which many members returned to their respective homes by the 3.42 train.

EXCURSION TO HERTFORD AND WARE.

SATURDAY, 22ND JUNE, 1878.

Directors—The President, Professor MORRIS, F.G.S., and JOHN HOPKINSON, Esq., F.L.S., F.G.S., Hon. Sec. Watford Nat. Hist. Soc.

(*Report by* Mr. HOPKINSON.)

The northern edge of the London Tertiary Basin passes for a considerable portion of its course through the county of Hertford, and within the last few years several places along this line of outcrop have been visited by the Association, in conjunction with the Watford Natural History Society and Hertfordshire Field Club. On this occasion the neighbourhood of the county town was selected for investigation, and Members of the two Societies met at Hertford Station at half-past ten, the local Field Club forming by far the larger party.

The first place visited was Hertford Castle, near which there are still standing, completely overgrown with ivy, the ruins of a much older structure, once an important fortress, supposed to have been built by King Alfred.

From the Castle the route lay through the churchyard, famed for its fine avenue of chestnuts, 200 years old, and thence by permission through Ball's Park, the seat of the Marquis Townsend, to Mr. Lines' brickfield, between Rush Green and Little Amwell, the first point of geological interest. Before, however, the brickfields were visited, a chalk-pit near afforded Professor Morris the text for an interesting address, in the course of which he showed that the flints immediately above the Chalk were of a different colour to those in the Chalk, some chemical change having given them a green coating. The presence of this bed of green-coated flints, known to borers as the Bull's Head Bed, was a proof that we had the true surface of the Chalk, the bed forming the basement of the Tertiary Series. Another interesting point connected with the Chalk here, was that it contained very little silex, for it had segregated in the form of flints; while, in the Chalk without flints, the silex was probably distributed through the mass. Mr. Lines, who here joined the party, stated that in the bed above-mentioned sharks' teeth and oyster shells (*Ostrea Bellovacina*) were frequently found.

Various sections exposed in the brickfields were then examined,

the Professor explaining the relative position of the different beds, and their relations to each other, and to beds elsewhere which are here wanting. In this district he said that we had the lowest portion of the Tertiary Series seen north of London, but not the lowest known in the London area, for while the Thanet Sands were being deposited south of the Thames, the Chalk here was nearer the surface, not allowing of their deposition. The Woolwich and Reading Beds also were only partially represented. They consisted of alternations of sands and clays, and showed a very different set of conditions to that on the south of London, where there were 30 or 40 feet of ash-coloured sands. Here there were no freshwater shells, though these beds were contemporaneous with the freshwater beds found at Lewisham, &c., which contained a great number of shells. While south of London there were fresh-water and estuarine conditions, in the north and west the deposits were entirely marine.

Other beds which form a passage between the Woolwich and Reading Series and the London Clay, were next examined, and Professor Morris stated that they represented an important change of conditions. Their black flint-pebbles were interesting as being derived from unworn flints perfectly rolled on some sea-shore, and after being rounded, spread over the surface, where they were now found. These higher beds, the Basement-bed of the London Clay, evidenced a great depression of a very large area, extending between Marlborough, Hungerford and Harwich.

From the brickfields the route lay across the fields to Little Amwell, near Hertford Heath, the highest point visited during the day, where excavations are in progress for a reservoir to supply the village with water. Here the Professor continued his lecture on the geology of the neighbourhood. Few districts were, he said, so interesting geologically as this and the adjacent ones which had been partly worked out by Professor Hughes. Other heights of the same level were seen around, and these elevations were the remnants of a surface of uniform height which had been cut into deeply by denudation, the present river-valleys being formed and gravel deposited. The gravel beds, of the higher levels, might be seen to contain pebbles from a great distance—Wales, Cumberland, and Scotland. They were the high-pebble gravels of Professor Hughes. It was improbable that they were here first formed in place as pebbles, some at least being pebbles of far older age. After the pebbles were deposited an emergence took place, and the land

became scooped out, and great valleys were formed. During a period of submergence the Glacial or Boulder-clay materials were brought from the North; and here the Boulder-clay was seen to have mixed up the gravel of high-pebbles, and brought with it other materials. After this period a partial emergence took place, and after this emergence rain and rivers gave the present contour to the country, forming the third or River-gravel period, so that the district now presents the beds of High-pebble gravel, Boulder Clay and gravel, and Low-pebble gravel.

From Little Amwell the route lay through the Walnut-tree Walk, and in refreshing shade, for the day was hot and the sun shone brightly, a halt was made for luncheon, after partaking of which the party passed through Amwell Bury, the romantic grounds of the Rev. D. Barclay Bevan, by permission of the Misses Bevan, and came upon the high road near the Amwell Hill lime-kilns, where a few fossils were found, and some fine examples of vertical "pipes," exposed at the sides of an extensive chalk-pit, were specially noticed.

Climbing one of the sides of the pit, Amwell Magna was almost immediately reached, and the well-known spring which rises here from the Chalk, affording the New River Company a copious supply of water, was visited; but the beauty of the spot—the church above, the river flowing by, the finely-wooded hill-side, and the ornamental water reflecting the varied scene—diverted attention from the spring, and the interest attaching to its situation and origin. It is evidently a subterranean stream, flowing for some distance in the Chalk towards the river Lea, then passing under it and rising on the other side, and finding its way to the surface close to the river under which it flows.

The next point of interest was near the New River Head, on the road from Ware to Hertford. Here the Diamond Rock Boring Company are boring for an additional supply of water for the New River Company. On arriving at the scene of operations, the party, by permission of the New River Company, and of Colonel Beaumont, C.E., Director of the Diamond Rock Boring Company, had the opportunity of becoming acquainted with the various methods of working adopted. The first operation consists in boring by means of compressed air—men working inside an iron cylinder into which air is pumped, which drives out round the edges any water which may accumulate, and materials which are loosened inside, while the cylinder is forced down from above. This preliminary

process had been given up, and the boring by diamonds had been carried on for some time. The shaft, commenced in February, had been carried to a depth of about 250 feet, a quarter of the entire distance intended, at an expense in diamonds alone of over £400; for although the diamonds rapidly cut away the hardest rock without showing any signs of wear, they become loose and break away by the wearing out of the steel socket in which they are fixed. They are set in rows tangentially at the bottom of a ring of varying dimension, the larger rings which are first used, being made to revolve more slowly than the smaller ones used at greater depths, where the bore-hole has to be smaller. At the present stage, a ring of 19½ inches in diameter, making from 100 to 125 revolutions per minute, is being used, the motion being given by a 25-horse power steam engine. After this explanation, the foreman of the works most obligingly set his men to give a practical illustration of some of the processes, and the method of drawing the "core" and the "sludge" was duly exemplified.

The Chadwell Springs, a few fields distant—better known as the New River Head—were next to have been visited, and the "Ermine Street," an old Roman road, and other indications of olden times, to have been explored, but evening was drawing near, and the party had to hasten from the boring to Ware Priory, the residence of Dr. J. Gwyn-Jeffreys, F.R.S., &c., who had invited the Members of the two Societies to tea. Here a sumptuous meal was provided, and after full justice had been done to it, Professor Morris, as President of the Geologists' Association, proposed a vote of thanks to Dr. and Mrs. Gwyn-Jeffreys, for their kind entertainment, which was seconded by Dr. Brett, as President of the County Society, and carried by acclamation.

Dr. Gwyn-Jeffreys, in responding, referred to the long and tiring walk his visitors had accomplished, which he was sure was good for them, and for the ladies especially, of whom he was glad to see so many present. He was very pleased to see them all at the Priory, and hoped this would not be the last visit they would pay him.

The party then took leave of their host and hostess, and left the Priory for Ware Station, the Members of the Geologists' Association returning to London by the Great Eastern Railway, and the Members of the Watford Society to Hertford, in the opposite direction, and thence to Watford and elsewhere.

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